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Patterns and Concentrations of Risk in Reported Police Pursuit Incidents in New Zealand

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Abstract

Overseas pursuit research has grown since the 1980s and this research has identified crash risk concentrations across a variety of pursuit variables. This type of research has not previously been conducted in New Zealand. The present study explores general descriptive pursuit statistics, and patterns and concentrations of crash risk across New Zealand pursuit variables using nationwide pursuit data. Previous research was used to identify variables that would be useful for further analysis using the New Zealand data. Variables were categorised into an input, output and outcome model, then bivariate analysis was conducted using cross-tabulation and *t*-tests to identify associations between these variables and pursuit crashes. Further research is required to better understand pursuit benefits. However, it appears that pursuits involving fleeing drivers who are children and young people pose an excessive risk, especially when in stolen vehicles. Current police pursuit tactics, like air support use, might not be meeting crash prevention expectations and this issue needs to be investigated further. A power few analysis was conducted analysing pursuit count per officer and pursuit crash likelihood. Associations were identified between gender and officers who engaged in more pursuits compared to officers who engaged in fewer pursuits. No association was found between pursuit counts per officer and crash likelihoods per pursuit. Consistent officer crash risk might indicate sound administrative oversight overall in New Zealand, but the results nevertheless point towards the need for a revised approach to pursuit policy and practice where some pursuits are restricted or discouraged. Some suggestions are also made for further research.

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Introduction

Police Pursuits

"A pursuit occurs when the driver of a vehicle has been signalled by Police to stop, fails to do so, attempts to evade apprehension, and Police take action to apprehend the offender"

(Independent Police Conduct Authority, 2009)

Police pursuits have been a problem in many jurisdictions for decades as police face the inherent difficulties of balancing obligations to enforce the law with obligations to maintain public safety (Alpert & Dunham, 1989; Alpert et al., 2000). Since 2004, New Zealand Police has had a more restrictive pursuit policy with increased training, reporting and accountability processes than were in place previously (New Zealand Police, 2010). Despite this policy, substantial harm still results from pursuits.

During the study period, 2011 to 2014 inclusive, there were 9,324 reported pursuits resulting in 1190 crashes (1 in 7.8 pursuits) during pursuits. Of these crashes, 199 (1 in 47 pursuits) were injury crashes and 7 (1 in 1332 pursuits) were fatal crashes. During the same period there were 430 (1 in 27 pursuits) crashes after pursuit abandonment resulting in a further 103 (1 in 91 pursuits) injury and 7 fatal crashes. The New Zealand Ministry of Transport (2014a) estimates the social cost of a fatal crash at $4,582,600, a serious injury crash at $485,000 and a minor injury crash at $27,500. Using these estimates the total cost to New Zealand society is clearly an important consideration to be assessed against the benefits of pursuit. To put pursuit risk in perspective, more people died during or shortly after pursuits than during or shortly after any other police arrest tactic or use of force. Internationally, more people are injured or die as a result of pursuits than police shootings (Hoffman, 2003), although pursuits are far more common than shootings.

These negative pursuit outcomes should be balanced against the potential benefits of apprehending fleeing drivers (Alpert and Lum, 2014). Many jurisdictions, including New Zealand, do not collect data on charges resulting from pursuit apprehensions and this makes any assessment of relative pursuit benefits difficult. Determining whether different types of pursuit are justified is therefore complex and hampered by limited data availability.

Developing pursuit policy is also complex. It is often argued that general deterrence justifies policies that allow pursuits (Alpert & Dunham, 1989; Alpert et al., 2000). The deterrent effect of different pursuit policies is not known (Homel, 1990). However, failing to apprehend fleeing drivers reduces the perceived severity and certainty of punishment, which Nagin (1998) states are key aspects of deterrence theory. Evidence of traffic enforcement's deterrent effect is more robust (see Zaal, 1994 for example). Sherman's (1990; 1992) discussions of the short-term deterrent effect of drink driving crackdowns and Homel's (1994) outline of longer-term general deterrent effects of a drink driving strategy involving random breath tests show that traffic enforcement involves evidence-based prevention approaches with useful deterrent value.

Where policy restrictions are being considered it is also difficult to determine what specific restrictions to apply. Fleeing driver behaviour is difficult to predict intuitively and information during pursuits is often limited. The very act of 'pursuit' may affect the fleeing driver's behaviour and therefore pursuit outcomes (Alpert and Lum, 2014). Fleeing driver and external factors are typically outside of police control. Police retain total control over the ability to initiate and abandon pursuits, however. It is important therefore to have as clear an understanding as possible of pursuit characteristics that are associated with crash risk when developing policy to ensure the best possible decisions can be made in the field about initiating and continuing pursuits.

Research in other jurisdictions, but not New Zealand, has identified targets for pursuit policy and practice improvements by highlighting where crash risk concentrates (e.g. Alpert and Dunham, 1989; Homel 1990; Alpert et al., 2000). However, research can only improve outcomes if it can be translated and adopted in practice and this can be complex (Nutley, Walker and Davies 2007). Policing has a long history of operating as a craft and relative to other sectors has only relatively recently turned to science to inform policy and practice (Sherman et al., 1998). In the absence of strong evidence, the police culture of experiential decisions and conventional wisdom continues to dominate operational pursuit decision making and pursuit policy development internationally (Alpert and Lum, 2014). The limitations of intuitive thinking like this are numerous (Kahneman, 2011).

Pursuit crash risk could concentrate in a relatively small number of officers. This type of concentration is what Sherman (2007) refers to as a power few concentration. Power few analysis is useful where concentrations can be identified as administrative and other interventions can then be targeted to maximise harm prevention benefits with the finite resources available to police agencies.

It is hoped that recent movements towards better use of evidence in the wider New Zealand public sector (Gluckman, 2013) will mean that New Zealand Police will increasingly become a consumer of research. Evidence will then be more likely to be applied in policy and practice. As pursuits result in death, injury and property damage it makes sense to give priority to applying an evidence-based approach to this aspect of policing. This thesis, which focuses on concentrations and patterns of crash risk aims to contribute to our empirical understanding of New Zealand pursuit harm and identify crash prevention targets. The research is therefore of interest to the wider community. This type of research has not previously been completed in New Zealand and is therefore an original contribution to the existing body of pursuit research literature.

The Present Study

From an evidence-based policing standpoint the database of reported pursuits New Zealand Police has maintained since 2004 is very useful. This database records a range of variables that may be used to explore patterns and concentrations of crash risk, including non-injury crashes (variables are listed in Appendix 1, p.85). The three separate research questions addressed in this study are:

1) What descriptive characteristics are found across pursuits generally?

2) What, if any, patterns and concentrations of crash risk exist in individual police, external, and fleeing vehicle and driver variables?

3) Is there a power few concentration of pursuits and crashes amongst lead police drivers?

The thesis begins with a review of available pursuit literature covering a range of different approaches and foci. As no New Zealand academic literature has been identified, government reviews and academic research from other jurisdictions provide the most useful available insights into crash risk factors. Overseas research also forms the primary basis for identifying variables for analysis and for comparisons between studies.

A discussion of data strengths, limitations and research methods applied in this study is presented next. As an administrative police database is used, there are important measurement reliability and validity limitations. The variables selected for analysis are outlined in an input, output and outcome model to show which variables are likely to be associated with crashes and should therefore inform risk assessments and policy changes.

Following this the thesis moves on to reporting results addressing the three research questions. A discussion of the study's findings then follows. The focus of this discussion is theory, comparison with other research, and policy implications. Any recommendations are made cautiously knowing that research into pursuit benefits is required to fully assess the relative costs and benefits of pursuits. The recommendations nonetheless have the potential to translate into improved policy and practice and therefore reduce pursuit crash harm.

Literature Review

This literature review considers a range of pursuit studies and focuses particular attention on research that analysed patterns and concentrations of pursuit outcomes. Particular attention was paid to variables that might show propensity for crash risk or concentrations of harm amongst officers. Searches for literature in this study have utilised several online databases and Cambridge University Library online catalogues. Searches were limited to English language studies and publications including the words police pursuit, pursuit driving, and use of force. Use of force was included in the review due to similarities with pursuit contexts and overlaps with pursuit research.

Criminological theory is also reviewed where it is applicable to police pursuits. Theories that help explain offender behaviour include deterrence theory and theories of desistance. Sherman's (2007) 'power few' idea of targeting resources provides important insights into analysis of harm concentrations amongst officers and is briefly outlined.

The three classifications of policy settings referred to in a number of studies (e.g. Alpert and Dunham 1989; Falcone and Wells, 1999) are useful to consider throughout as they provide a good framework for understanding different policy contexts. These classifications are: Judgemental Policy – allowing wide officer discretion; Restrictive Policy – implementing policy restrictions; and Discouraging Policy – pursuits are only allowed in exceptional circumstances and are generally discouraged.

New Zealand Reviews

The literature search identified no published academic research specifically relating to the New Zealand context or using New Zealand Police data. However, there have been several New Zealand Police pursuit policy reviews and reports. Some descriptive statistics were included in these reports (e.g. New Zealand Police, 1996). These are useful for comparison purposes, but the low reporting rate at the time adversely affected data quality in all reviews. The reporting rate improved substantially when an electronic reporting system and 2004 policy changes were implemented.

The most notable report was the New Zealand Police review: Pursuits: A Case for Change (New Zealand Police, 2003). This report led to change from a largely judgemental policy to the current more restrictive policy, albeit one without specific exclusions found in other jurisdictions. This was a comprehensive review of pursuit policy and reflected on both international research and practice. Chapter four of the 2003 review outlined a range of descriptive statistics from the New Zealand Police database maintained at the time. These descriptive statistics include numbers of reported pursuits, time of day, number of abandoned pursuits, offender demographics, vehicle types and percentage of pursuits involving a crash. There are several limitations to this analysis including the reporting level which varied from 446 to 785 pursuits per year (New Zealand Police, 2003, p.24) compared to 2391 reported pursuits in 2014. It is therefore likely that the reporting rate in 2003 was considerably lower than it is today, accounting for at least some of the difference in recorded pursuits. Alpert et al. (2000) highlighted the problem of under-reporting in pursuit data used in other jurisdictions' studies during this same era. As this review formed the basis of a comprehensive change to policy and practice, the report is also not reflective of contemporary New Zealand Police pursuit crash risk.

Notwithstanding these limitations, some interesting insights can be gleaned from the data. For example, the median length of service of police pursuit drivers was only 4 years and the median age was 31 years (New Zealand Police, 2003). The proportion of crashes at the time is also of interest for comparison with this thesis. Pursuit crashes occurred in 34.4% of reported pursuits over 7 years, compared to 12.8% from 2011 to 2014 (reported in detail in Results chapter). Due to the smaller number of reported pursuits in the 2003 review any conclusions about this figure should be treated with some caution especially when comparing with current figures. It seems likely that officers would report more pursuits involving a crash, which would affect measurement validity.

New Zealand Police's Road Policing Support Group completed further internal reviews (e.g. New Zealand Police, 2010). The Independent Police Conduct Authority (2009) also completed an oversight paper and published reviews of individual fatal incidents. These are useful for understanding the context of pursuits in New Zealand and use the same database as this thesis. However, there has not been any robust statistical analysis of risk factors completed and published as has been conducted in some other jurisdictions, such as Queensland, Australia (Hoffman and Mazerolle, 2005) and Miami, USA (Alpert et al., 2000). There is therefore an opportunity to fill this gap.

International Literature Overview

The pursuit's literature has historically not been as comprehensive as other policing areas such as police shootings (Alpert & Fridell, 1992). Alpert and Dunham (1989) went as far as to say that little was known about this policing tactic at the time of their study. However, the evidence base has become much more extensive since the early 1990s. Some studies have looked at specific cases of pursuit-related death (Queensland Criminal Justice Commission, 1998). Other studies have looked at police training needs (Alpert, 1997) and some have focused attention on legal precedents (Alpert & Smith, 2008). Studies have also used statistical analysis to identify variables most likely to lead to different outcomes including crashes (e.g. Alpert & Dunham, 1989; Senese & Lucadamo, 1996; Crew, Friddell & Pursell, 1995; Alpert et al., 2000; Hoffman & Mazerolle, 2005). There have also been studies that used interviews to ascertain police officer and fleeing drivers' attitudes to pursuits (e.g. Homel, 1990; Homant and Kennedy, 1994). Homant and

Kennedy (1994) for example found that male officers were associated with a more positive attitude towards pursuits.

The risks of pursuits are so high that many authors discuss pursuit driving in a similar context to police shootings and other uses of force (e.g. Beckman, 1983; Fyfe, 1990; Alpert and Fridell, 1992; Alpert et al., 2000). Beckman argued that pursuits could be considered 'deadly force' (1983, p.34). Alpert et al. highlighted these similarities between pursuits and police shootings by discussing the same 'competing values' (2000, p.15) of each police action in regards to enforcing the law and protecting life. Both arrest tactics involve a high chance of negative outcomes including risk to innocent members of the public. The parallels in terms of deaths and injuries caused are rather obvious; what is not obvious to many practitioners who feel they have a 'duty to pursue' (Alpert et al., 1996) is the level of risk to life and property from crashes (Alpert et al., 2000). This disconnect between the views of police scholars like Alpert et al. (1996; 2000) and many practitioners may be reduced by producing more sound evidence of differing levels of pursuit crash risk. As Alpert and Dunham (1989) stated, the lack of reliable data in the early stages of police pursuit research allowed a wide range of conflicting views to develop. Notwithstanding the growth of research evidence in other jurisdictions since then, these diverse views have endured to a large extent as has the need for further evidence-based research.

Other jurisdictions have also made reviews publicly available. For example, a Welsh review (Best & Eves, 2004) of pursuits provides a good point of reference against the New Zealand Reviews. This review showed the benefits of additional variables not found in the New Zealand data, such as traffic and weather conditions.

Descriptive Studies

One of the earliest comprehensive descriptive pursuit studies was a California Highway Patrol study in the 1980s (as cited in Alpert et al., 2000). This study confidently claimed pursuits should be continued and were worth the risk posed, which as pointed out previously can be considerable (Alpert et al., 2000). By the early 1990s more research was being undertaken in different jurisdictions including elsewhere in the United States (e.g. Alpert & Fridell, 1992) and in Australia (e.g. Homel, 1990). The conclusions of these studies were generally far less supportive of the tactic.

Alpert et al. (2000) summarised descriptive statistics identified in several United States studies. What is immediately apparent from these comparisons is the very low rate of reported abandoned pursuits in these jurisdictions at the time, combined with very high rates of negative outcomes relative to contemporary New Zealand figures. In New Zealand 51.1% of pursuits are abandoned and 12.8% end in a crash (reported in detail in Results chapter). Rates of abandonment ranged from around 4% in California and Minnesota, 5% in Miami-Dade and 10% in Illinois (Alpert et al., 2000). In a Perth, Australia study the abandonment rate was 8.4% (Homel, 1990). Crash rates varied from 23% in Minnesota, 29% in California to 39% in Illinois (Alpert et al., 2000). In Perth the crash rate was 26.3% (Homel, 1990). These studies were all conducted in the 1980s or 1990s and much has changed since then in regards to policy and reporting processes.

A number of studies have analysed both positive and negative pursuit outcomes. This existing evidence base is therefore helpful to identify variables that are useful for analysis. For example, Alpert and Fridell (1992) reported that in one North American police agency 11% of pursuits were initiated for BOLO (be on the look out) dispatches. BOLO is a North American term for a broadcast from a Communications' Centre to officers to look for a vehicle of interest. Bivariate analysis showed that pursuits of this kind had the highest proportion of arrests and crashes (Alpert & Fridell, 1992). This variable is likely to also be an important area for research in the New Zealand context as officers are often provided information about vehicles and people to look for in the course of their patrols.

Homel (1990) extended research to police decision-making, finding that aboriginal offenders were more likely to be pursued, as were fleeing drivers who intentionally collided with police cars. Most pursuits were initiated for traffic offences, stolen vehicles or mere suspicion of criminal offending, whereas few pursuits related to serious criminal offending in Perth (Homel, 1990). This finding is contrary to the belief of many practitioners and others that the very act of fleeing is indicative of 'something being amiss' (New Zealand Police, 2003, p.6) and more serious offending having been committed (Hoffman and Mazerolle, 2005). Hoffman and Mazerolle (2005) found that few fleeing drivers were charged with more serious offences than already known during a pursuit. However, Alpert and Dunham (1989) reported that half of fleeing drivers were charged with serious offences unrelated to pursuit, which supports this belief.

Alpert (1997) found that speed, residential area, number of police cars and cross-jurisdictional pursuits predicted injury outcomes. In another study, pursuits in urban areas were more likely to end in a crash than pursuits in rural areas (Alpert et al., 2000). Alpert and Dunham (1989) found the main predictive variables for crash or injury outcomes were officer age (officers in 20s more likely), officer ethnicity (Anglo American more likely), officer gender (males more likely), pursuit reason (traffic more likely), time of day (daylight hours more likely), road type (freeway less likely than other roads) and wet roads (more likely).

The importance of officer characteristics and their relationship with crashes has been less than clear in other literature (e.g. Homel, 1990; Alpert et al., 2000). The lack of association in some studies could be due to the effect of clearer policy, training and oversight homogenising officer decision-making as Alpert et al. (2000) suggested. Sherman (1980) outlined varying results from studies of officer characteristics and performance in his overview of causes of police behaviour research. Although Sherman (1980) did not consider pursuits, associations were reported between demographic characteristics and other policing outcomes. In any case, it will be useful to conduct this analysis of associations between officer demographic variables and pursuit crashes in New Zealand given that associations have been found in relation to pursuit and other policing outcomes in some jurisdictions.

Along with studies that investigated pursuit behaviour generally, there are also studies that looked primarily at one variable. Alpert's (1998) study of helicopter use during pursuits in the United States police agencies of Baltimore and Miami-Dade is a good example of a study that focused on just one variable. Alpert (1998) found that helicopters led to very high arrest rates of 83% in Baltimore and 91% in Miami-Dade. There was no analysis of crashes in this study, although the author does mention that helicopters reduce risk.

Alpert's (1998) study provides a good example of why research is needed in all jurisdictions as findings cannot always be generalised with confidence across agencies or countries. Baltimore had a discouraging policy and Miami-Dade only allowed pursuits for 'violent felonies' (Alpert, 1998). The contexts in these studies were therefore very different to New Zealand, which has a restrictive policy, but in practice allows pursuits to be initiated for very minor offences. Both United States agencies also actively used helicopter searchlights to illuminate the offending vehicle's location and road where headlights are turned off (Alpert, 1998). These are not commonly used tactics in New Zealand where the helicopter is typically used covertly to avoid provoking dangerous driving.

Previous literature looked at similar research questions and several used similar methodologies to the present study. For example, Alpert et al. (2000) used cross-tabulation to illustrate the crash likelihood of various variables. Crew, Friddell and Pursell (1995) used a similar approach to show odds and probabilities of variables and pursuit outcomes. Hoffman and Mazerolle (2005) used statistical analysis to look at variables related to serious injury and fatal pursuit crashes and to pursuits generally in Queensland, Australia.

A negative outcome is not the only possible dependant variable when analysing pursuits. An apprehension is the positive outcome that police actions are intended to achieve. Combining analysis of all outcomes and attempting cost-benefit analysis is rather ambitious and complicated as, amongst other things, there may be more than one outcome from a pursuit. For example, the vehicle may crash and the driver may be apprehended. However, Crew, Friddell and Pursell (1995) used this approach. They considered reason for pursuit as an important variable for determining outcomes. These reasons were: traffic, drink driving, warrant, felony (broadly equivalent to a crime in the New Zealand context) and 'other'. They concluded that felonies and drink driving were most likely to lead to negative outcomes, which they defined as deaths, injuries and property damage crashes. Positive outcomes were defined as apprehensions. Some conclusions were also drawn about which pursuits are more likely to result in better outcomes.

Crew and Hart (1999) took an altogether more complicated approach in their study. They used an estimated dollar value for crimes fleeing drivers were apprehended for and used insurance and research data to quantify other pursuit outcomes. In their words, this methodology was ‘crude’ (Crew and Hart, 1999, p.60). Crew and Hart’s (1999) research was therefore a useful attempt to move towards a quantitative assessment of pursuit value even though it appears to fall short of providing robust evidence.

One problematic aspect of the body of international pursuit research is that each study focused on state or local police agencies’ data. Alpert and Lum (2014) noted that there is no national pursuit database in the United States, where most pursuit research has been conducted. The lack of a national database inhibits research in that country as data collection inconsistencies limit comparisons and generalisations. It also means that variables considered in previous research are not comprehensive, as there are no guidelines ensuring that all agencies collect the same useful data (Alpert and Lum, 2014).

Evaluations

Robust quasi-experimental and experimental evaluations of policies and outcomes are non-existent in the evidence base of pursuit research and no studies at Level 3 or above on the Maryland Scientific Methods Scale (SMS) (see Sherman et al., 1998 for explanation) were identified in this literature search. The difficulty of conducting an experiment where pursuits are randomised probably makes this approach unrealistic (Alpert & Dunham, 1989). Quasi-experimental evaluations of policy change and outcomes comparing test and control areas seem possible, albeit probably still difficult to undertake in practice. Homel (1990) recommended that the Western Australia Police cease pursuing fleeing traffic violators for a period of three months to evaluate the effects of this proposed policy change. This evaluation was not undertaken although this type of testing is needed to create a strong evidence-base demonstrating cause and effect of different policy settings.

Crew (1992) completed a before and after study (Level 2 SMS) of a restrictive policy in Houston, USA. The restrictive policy's implementation correlated with reduced pursuit numbers (outputs), but the study did not consider crashes and apprehensions (outcomes). The lack of control group, such as a similar city where policy did not change, also meant that it could not reliably provide causal inferences even if it had considered outcomes. The introduction of a restrictive policy in Queensland, Australia in 2008 also led to a substantial reduction in pursuit numbers (Lyneham & Hewitt-Rau, 2013), although no publicly available evaluation could be located.

Several authors (e.g. Brewer & McGrath, 1990; Homel, 1990) recognise the lack of pursuit policy evaluations and instead refer to research conducted on police shootings for evidence of potential policy and tracking effectiveness. Despite the study's relatively weak, Level 2 SMS design, Fyfe's (1979) study of a restrictive police shootings policy and tracking method shows how increasing policy restrictions can in some circumstances reduce police involved harm substantially with few negative side effects. The 2004 New Zealand changes could possibly have been evaluated this way, as could more recent policy changes in Queensland, Australia (Lyneham & Hewitt-Rau, 2013) or Milwaukee, USA (Alpert & Lum, 2014). This thesis will not attempt to fill this gap in pursuit evaluation research, but it does aim to highlight crash-risk concentrations that could be targeted and tracked during future policy reform. An evidence-based policing approach would involve evaluating any changes subsequently implemented as Homel (1990) recommended, and Fyfe (1979) undertook in relation to police shootings.

Policy and Judicial Review

Not all pursuit research has focused on what happened during pursuits or the outcomes of these incidents. Falcone and Wells (1999) assessed the characteristics of policies in 288 police agencies outlining how policy reform was largely driven by legal liability rather than evidence. Shuman and Kennedy (1989), Alpert et al. (2000) and Alpert and Lum (2014) all argued that legal liability was a key driver of pursuit policy changes in the United States. Clearer policies started growing in the early 1990s specifying procedures and restrictions on pursuit tactics. Lyneham and Hewitt-Rau (2013) noted that State Coroners drove policy change in Australia. The level to which evidence informs policy and judicial processes as opposed to liability and public opinion is difficult to specify from the literature. Evidence appears secondary to judicial review in influencing pursuit policy reform, however.

Criminological Theory

Because there is currently no specific theory to explain pursuit behaviour criminological theory is considered. As Alpert and Dunham (1989) noted, general deterrence theory is often referred to when arguing in favour of less restrictive and more judgemental pursuit policies. Deterrence is considered by many to apply to both traffic offences and crime control (Alpert & Dunham, 1989). Several authors (e.g. Alpert and Dunham 1989; Homel, 1990) noted the widely held belief amongst practitioners and others that restricting or discouraging pursuits would lead to significant increases in lawlessness. The 2010 New Zealand Police review, for example, suggested this widely held concern (New Zealand Police, 2010). As Homel pointed out, this belief, with its roots in deterrence theory, is 'unproven' (1990, p.16). In other words, it has not been tested using scientific methods. This does not of course mean the claim is untrue. It does, however, mean that the claim is not evidence based. Beckham stated that the claim that general deterrence justifies pursuits is 'difficult to believe' (1983, p.37) and Fyfe stated there is 'little to support such a premise' (1990, p.117). On the other hand, as Wikstrom (2008) noted, certainty of apprehension and celerity of punishment are key aspects of deterrence theory. Being allowed to flee and escape would therefore run contrary to this theory. Testing deterrence from pursuits in an evidence-based context could prove difficult and has not been attempted. Crew and Hart (1999) stated that there are no data available that can clearly link the number of arrests stemming from police pursuits to a general deterrence of crime.

In regards to specific deterrence, Homel (1994) quoted an offender interview suggesting that in at least some cases pursuits exacerbate offending rather than prevent it. Despite the limited available evidence either way Homel (1990) suggested that the specific deterrent effect is likely to be low, given that the same offender names reappear across the database used in their study.

Offending and age have long been recognised as related (Gottfredson & Hirschi, 1990). This connection has been demonstrated in consistent replications of the age-crime curve, which peaks in late adolescence then declines (Bottoms, 2010, 2014). Bottoms (2014) discussed a range of theories of desistance that help explain why this distinctive and pronounced distribution of crime occurs. These theories include the effects of employment and social bonds, for example. It is likely that both fleeing drivers and pursuit harm caused by fleeing drivers also follow this pattern, and therefore provide insights into pursuit risk. Gottfredson and Hirschi (1990) also outlined evidence of association between age and crime, as well as gender and race as influencing propensity to commit crime. The authors suggested that age and propensity to crime has not changed in 150 years despite changes in society and arrest rates or when genders and jurisdictions are compared (Gottfredson & Hirschi, 1990).

Gottfredson and Hirschi (1990) suggested that low self-control may explain criminality and low self-control reduces with age due biological and social control factors. Low self-control might explain some fleeing driver behaviour where young offenders make high-risk decisions or where other criminality is linked to their decision to flee. Self-control theory has also been used to explain officer misconduct (e.g. Donner & Jennings, 2014).

Homel (1990) and New Zealand Police (2003) reported the age of apprehended fleeing drivers and both data sets followed the age-crime curve pattern. Gottfredson and Hirschi (1990) report a similar pattern for traffic crash propensity as for crime, suggesting a disproportionately high risk posed by young drivers, which drops sharply until about the age of 30 years. A heightened risk posed by young drivers in Western Australian pursuits has also been noted (Homel, 1994). There appears therefore to be a gap in research about the level of risk posed by children and young people in New Zealand pursuits and a good chance that a concentration of crash risk will be identified.

Power Few

Sherman (2007) identified a possible solution to the problem of criminal justice experiments not finding large effect sizes for interventions. A solution proposed was to target resources where the most harm is concentrated amongst what is termed the 'power few' concentration of harm in a relatively small proportion of any unit of analysis (Sherman, 2007). In regards to pursuits this analysis of harm concentrations could be conducted with either fleeing drivers or officers to determine concentrations of harm. Officers are considered most likely to be useful for targeting as police agencies have inherently more control over their behaviour through training and oversight which can lead to more consistent officer behaviour (Alpert el al., 2000). While the present study does not involve an experimental approach to criminology as Sherman (2007) discussed, analysis of the extent of any concentration of harm will instead be very useful to ascertain the potential value of focused policy or administrative interventions. Sherman's (2007) suggested approach is therefore potentially of important value in practice.

Summary

A growing body of research has developed around police pursuits since the pursuit research landscape was rather sparse in the 1980s. Most research involves descriptive statistics which vary across jurisdictions. The variation between studies may be partly explained by inconsistent data collection. What does not vary is the presence of at least some level of negative outcomes wherever pursuits are permitted. The mix of positive and negative outcomes creates a conflict in objectives between police law enforcement obligations and obligations to maintain public safety.

Previous research has identified concentrations and patterns of likelihoods for crashes, injuries and apprehensions across other jurisdictions' pursuits. It includes overviews of descriptive statistics showing different outcomes in different places. What it does not do is analyse the likelihood of pursuit crashes occurring in New Zealand, or whether there is a power few concentration of harm amongst New Zealand officers. These are important gaps that this thesis will help address.

Methods

This thesis explores general descriptive statistics found in the New Zealand pursuit data, highlights concentrations and patterns of crash risk, and identifies whether some lead police drivers pose a particular risk that is associated with their pursuit counts. Most statistical analysis used, such as cross-tabulation and *t*-tests, has been applied in previous pursuit research (e.g. Alpert et al., 2000). This thesis applies some of these approaches and presentation styles to assist with comparisons.

This chapter starts by clarifying definitions. Data used in the study is then described including an overview of data quality and limitations. An input, output and outcome model is then presented which lists and categorises pursuit variables. This model also describes how the variables interrelate and which variables police can control. This is followed by an outline of the research design used to address the three research questions: What descriptive characteristics are found across pursuits generally?; What, if any, patterns and concentrations of crash risk exist in individual police, external, and fleeing vehicle and driver variables?; Is there a power few concentration of pursuits and crashes amongst lead police drivers?

Definitions

Key terms are outlined in the following paragraphs. Other useful definitions are outlined in table form in Appendix 2 (p.86) to assist with reader clarity (Bachman and Schutt, 2014).

Pursuits

There is no internationally consistent definition of pursuit. The definition applied when data was entered into the database, and is consequently applied in this study, is: 'a pursuit occurs when the driver of a vehicle has been signalled by Police to stop, fails to do so, attempts to evade apprehension, and Police take action to apprehend the offender' (Independent Police Conduct Authority, 2009). New Zealand Police currently refers to pursuits as fleeing driver incidents.

Lead Police Drivers

Lead police drivers are the focus of Question 3. They are defined as the officer driving the police car at the time a pursuit was initiated. These officers enter most details submitted to the pursuit database. Where pursuits are abandoned and reinitiated, these incidents are treated as separate pursuits with their own reporting processes.

Data Sources

Secondary data analysis is undertaken using the nationwide New Zealand Police pursuit database. New Zealand Police is a national police service with 9063 constabulary employees (New Zealand Police, 2014) and has responsibility for the vast majority of policing services across the country. New Zealand is slightly larger than the United Kingdom and has a population of around 4.5 million people. The database is administered by Police National Headquarters and is collected on an Excel spreadsheet by taking snapshots of a Lotus Notes-based reporting system. A flow diagram of the reporting process is found in Appendix 3 (p.87).

The data entry process is considered relatively robust compared with other pursuit studies, especially given the database's size. An automated electronic form is used with several layers of review. The electronic process improves promptness and data quality, whereas previous studies often used paper records (Alpert et al., 2000).

The Communications Centre Dispatcher first enters an event code 'PURSUIT' in the computer dispatch system to 'log' the pursuit. The Pursuit Controller is then prompted to start the reporting process and enters the first details into the Lotus Notes system. The

Lotus Notes system sends an automated email to the lead police driver for further detail to be added. The officer adds details and sends the report to their supervisor for review. The supervisor then requires changes or sends it to the District reviewer and Police National Headquarters. Automated email reminders are sent if each stage is not completed in the required timeframes.

Data Limitations

Measurement reliability refers to how well data collection has consistently measured each of the same variables, whereas measurement validity refers to measuring the same thing with the correct result (Bachman and Schutt, 2014). Measurement reliability and validity in this study depends on how the data were entered into the database and cleaned.

As Table 1 shows, despite the automated reminders, only 86.3% of records (8049 pursuit records) completed the review process. Consideration was given to removing records at earlier draft stages. However, these records were largely complete. Many were manually checked and found to have problems with narratives and not with variables. Variable data is therefore considered fairly reliable and were retained although this may affect measurement reliability to some extent.

The electronic data entry process is likely to lead to a higher reporting rate than previous studies that used paper-based reporting systems (e.g. Alpert et al., 2000). Because the form’s data entry process is started by the Pursuit Controller and reviewed by senior staff, there is also less opportunity for unreported incidents than if it was the lead police driver starting the process.

Table 1. *Status of pursuit database records*

Status	Frequency	Percent
Draft – Communications	100	1.1%
Overdue – Awaiting Initiating Staff Action	95	1.0%
Draft – Pursuits	71	0.8%
Overdue – Awaiting TDD Officer Completion	16	0.2%
Awaiting Supervisor Approval	1	0.0%
Overdue – Awaiting Supervisor Approval	221	2.4%
Rejected – Changes Required	68	0.7%
Awaiting District Review	703	7.5%
Review Process Completed	8049	86.3%
Total	9324	100%

Although the reporting system works in favour of measurement reliability and validity in some respects, there are limitations and some errors were found in the data. The database was not established for research and has many limitations such as free text fields, missing data, omitted variables and data entry errors. It therefore required substantial cleaning and coding by the researcher prior to being usable for research. This is a common disadvantage of using databases created for administrative purposes (Bachman and Schutt, 2014).

Due to the number of records it was not practicable to manually check them all. However, all fatal pursuits were checked against narratives and electronic file records. Two non-crash deaths were removed from the database. File records generally only exist for pursuits that the officer reported as a crime or crash and are not therefore a realistic alternative data source.

There were also some errors in records. Outliers were verified and where appropriate corrected by manually checking narratives against data. Duplicate records were identified by scanning the database for officer and offender duplications and were removed when duplications were confirmed. Duplicates or incorrectly entered records that could not be corrected were deleted (15 records). This number includes records where the officer recorded their pursuit speed as zero and stated there was no pursuit. Five speed limit records were changed to correct values by checking narratives for records where values were not possible designated speed limits, probably due to typing errors.

Despite being started by the Pursuit Controller, the form may be affected by being submitted as part of an accountability process. Incentives exist for biased reporting of variables that could reflect negatively on officers' decisions. For example, speed and duration could possibly be under-reported for this reason. The extent of any under-reporting was not deemed possible to determine. It is more likely to affect validity than reliability as the same incentives to under-report apply equally across pursuits with the same outcomes.

Omitted variables complicate analysis as there could be correlations between variables included and variables omitted causing spurious relationships (Stigler, 2005). For example, in the general population of road users weather is associated with driver speed and crashes (Theofilatos & Yannis, 2014), whereas only speed and crashes are recorded in the New Zealand database. When analysing speed's crash association it is not possible to control for the effect of the confounding variable, weather (among a host of other variables not included in the dataset). Omitted variables are, however, a common issue with secondary data analysis (Bachman & Schutt, 2014).

Another limitation is that most fields have some missing values. Most evidently, fleeing driver characteristic fields are missing when the fleeing driver escaped. When analysing fleeing driver variables a bias is possible. It was not feasible to determine how escaped and apprehended offenders' characteristics differed, other than the differences in pursuit characteristics. Any bias will affect generalisation to the total population (Hagan, 2005). The number of cases used for analysis is reported to show the extent of missing variables in different parts of the thesis.

Officer demographic variables were not recorded in the original database. Data was matched with Human Resource Department records and added to the database. This process was made especially difficult because the fields allowed free text making incorrect matches numerous and some manual linking necessary. A number of officer records could not even be manually linked to Human Resource records because officers had resigned or changed names making it impracticable to link (246 officer records). Officer ethnicity data is collected from officers on a self-identifying basis and may therefore be subject to a higher error rate than other variables.

Data have been measured consistently for most database variables since 2004. However, there have been some changes to policy and collection approaches since then including a 2009 change to injury data processes. In addition, complete years of speed limit data have only been collected since 2011. To avoid these changes and any seasonal bias calendar years were used for analysis from 2011 to 2014 inclusive, during which time data collection policy has been consistent. The final cleaned dataset included N=9,324 case records with 122 variables potentially available for analysis (list of variables in Appendix 1, p.85).

Ethical issues were considered. All data relating to individuals, including vehicles and names were anonymised using randomly assigned numbers prior to extracting data from the New Zealand Police computer system. No individuals could therefore be identified during analysis.

Research Procedure

The primary research method for this study is descriptive analysis. The focus for Questions 1 and 2 is reported police pursuits, whereas for Question 3 it is lead police drivers. The general research approach is a targeting and tracking study to identify where harm reduction may be improved by looking at where the predicted future risk of harm is highest (Sherman, 1992).

The first part of the methodology involved defining the main outcome variable for the three research questions. Consideration was given to analysis of fatal crash or fatal and injury crash outcomes. These options would be problematic because they are relatively rare outcomes meaning that the design might be underpowered to detect smaller associations even though the large sample size used will increase statistical power (Weisburd, Petrosino & Mason, 1993).

Despite the large dataset used some adverse affects could still occur due to the law of small numbers (Kahneman, 2011) when data is split into small sub-categories for descriptive analysis. The law of small numbers refers to smaller numbers of variables being affected more by random variation in the data, increasing the possibility of a relationship between variables appearing to exist when it does not really exist, or vice versa. To balance the weaknesses of various approaches the negative outcome analysed will be all crashes during pursuits, including property damage crashes.

Crashes a short time after pursuit abandonment are not included due to the different incident context. Many fleeing drivers slow down or stop after police abandon pursuits (Alpert et al., 2000). Furthermore, a number of variables, such as speed are not recorded once the pursuit is abandoned.

The order variables occur and which ones police control is important to understand so the findings can be more easily applied in practice. Figure 1 illustrates an input, output and outcome model arranging variables logically. A similar model has been used in other policing research to illustrate solvability factors (e.g. Coupe, 2014) and these models are a familiar aspect of New Zealand public management (Boston, et al., 1996). Police have direct control over their inputs and outputs, but very limited control over external and fleeing driver variables. All three sets of variables are believed to cause different outcomes. However, relationship directions are not tested for in this largely descriptive study.

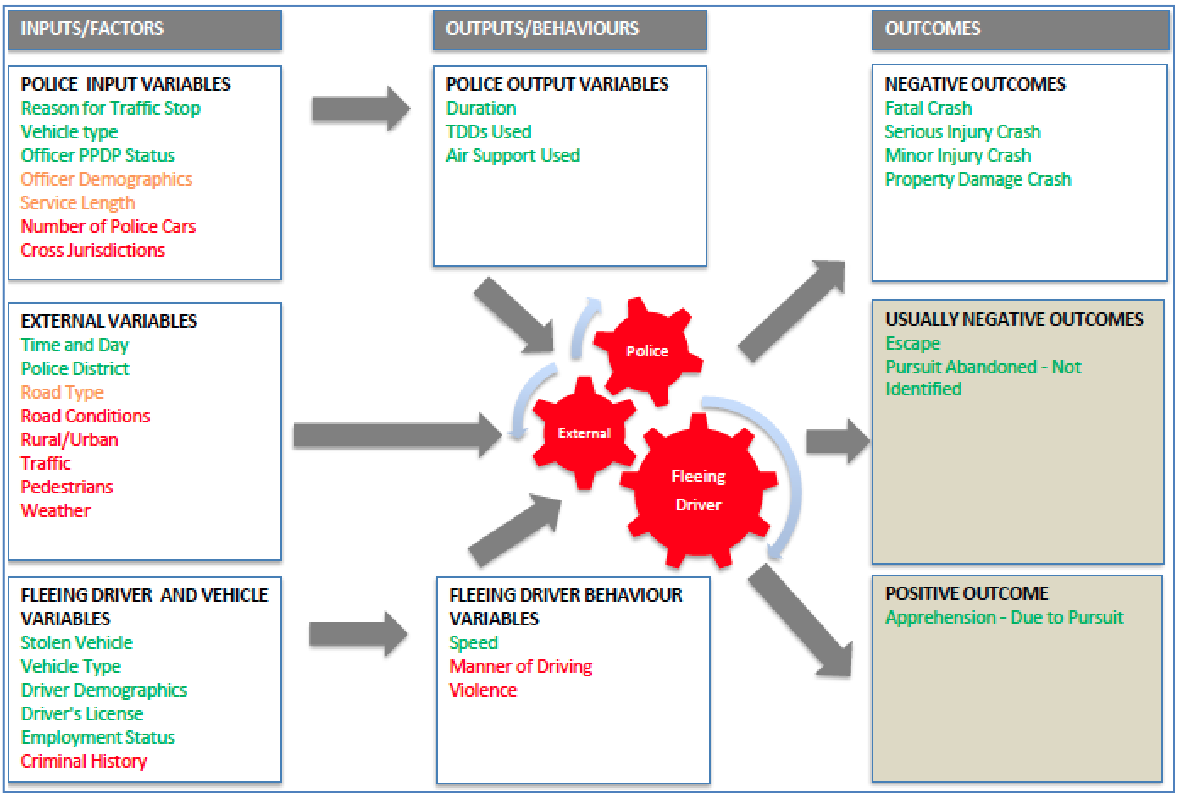

Figure 1. Pursuit input, output, and outcome model showing which variables are relevant for analysis, of these variables which ones are available to be analysed (green and orange variables) and which variables are not available to be analysed (red variables). White boxes are directly relevant to crash risk, whereas the light grey boxes relate to outcomes that are outside of this study's focus.

Selection of the model's variables was informed by previous research discussed in the literature review chapter. Variables are colour-coded to show data availability. Green variables were recorded and available. Orange variables were not recorded, but have been obtained from other sources. Red variables were not available in the database and were not practicable to obtain.

Some omitted variables might have been more useful than others. Weather, traffic conditions and the number of police cars involved are not included in the database, but would be useful for example. Pursuits that cross jurisdictions are also not included, but are likely to be less of a factor with one national police service. Because the database includes some other variables, namely officer Police Professional Driver Programme (PPDP) status and police vehicle type, these were also selected for analysis because their inclusion in the accountability process indicates that they are thought to associate with pursuit outcomes.

Some data have been pooled using a lookup function to reduce the number of category levels. Often this was because free text fields caused very large lists of categories as was the case for ethnicity and occupation. Some age analysis involved categorising values into brackets principally to analyse the level of risk posed by children, young people and young adults. Pursuit durations were pooled into categories to avoid data problems due to officers rounding values and because pursuits less than one minute long were rounded to zero. Road types were grouped by pooling speed limits into urban, arterial and highway/rural groups as defined by the New Zealand Transport Agency (2003).

The speed measure chosen for analysis is the speed differential because police commonly use this measure in practice to assess risk and make abandonment decisions. This was calculated by the subtracting the top pursuit speed from the speed limit.

The main analytical method used is cross-tabulation with chi-square analysis. Cross-tabulation is a useful approach as it effectively shows the likelihood of different outcomes given the presence of other variables when categorical data is used. This is similar to a conditional probability as used in other policing research including the development of hot spots policing (Sherman, Gartin & Buerger, 1989) and in the power few analysis section of the present study. Put simply, conditional probability tells us the chance of a defined outcome occurring given that we know an event has already occurred (Gosling, 1995). Cross-tabulation used in this study shows different variables that precede the outcome (crashes) in time, whereas conditional probabilities generally report the likelihood of the same outcome occurring again.

While it can be argued that this dataset is close to a total population of New Zealand pursuits from 2011 to 2014 it could also be argued that it is a sample. For example, it is not a total population of all pursuits as a time period has been selected and extracted and some variables have a lot of missing data, especially fleeing driver variables. Consideration was given to expanding the time frame extracted. However, the four-year timeframe is considered to provide a good balance of sample size and measurement consistency.

Significance testing was used to see if some groups in the population are different from one another in terms of outcomes. An alpha level of 0.05 was applied for rejecting the null hypothesis of no association in all statistical tests. Because the dataset is large it is important not to overstate the practical significance of small but statistically significant results.

Research Questions and Data Analysis

Research Question 1: What descriptive characteristics are found across pursuits generally?

Descriptive statistics were generated using Excel and SPSS to show pursuit patterns, the proportion of harmful pursuit outcomes and the distribution of pursuits across variables, such as pursuit durations. This provides a basis for comparisons with studies in other jurisdictions. It also indicates where concentrations of harm might be found. Interval data was applied to frequency distributions and histograms to identify patterns (Ruane, 2005). The mean, median and standard deviation are reported for interval data, whereas modes and percentages are reported for nominal and ordinal data (Bachman & Schutt, 2014).

Research Question 2: What, if any, patterns and concentrations of crash risk exist in individual police, external, and fleeing vehicle and driver variables?

Bivariate analysis was used to test associations between the variables listed in Figure 1 and crashes (negative outcome in Figure 1). Bivariate analysis was applied and presented in a similar way to other pursuit studies such as Alpert et al. (2000). This replication provides a useful framework for comparisons while addressing the research questions in a logical way. Phi and Cramer's V statistics are reported to indicate association strength and are presented in a similar format to previous studies, also for comparison purposes. Reporting Phi and Cramer's V statistics is important as chi-square tests on their own only show whether the association is statistically significant, not the association's magnitude. Cohen's conventions (as cited in Privitera, 2015) recommend interpreting Phi (1 *df*) as: 0.10 small, 0.30 medium and 0.50 a large effect size, and Cramer's V (>1 *df)* conventions as small 0.07, medium 0.21 and large 0.35. To give the results context though, Alpert et al's (2000) study conducted 16 chi-square tests for similar pursuit variables to the present study. Eleven of these reported Phi values lower than 0.1 and 4 were higher than 0.1, but lower than 0.2. In the present study odds ratios were calculated for 2x2 tables using the SPSS risk value function. An odds ratio shows the relative likelihood of an outcome for one group compared to another.

Adjusted standardised residuals were calculated for chi-square tests with greater than 1 degree of freedom (>2x2 table) as this will show us which observed frequencies differ significantly from expected frequencies. Cells with higher than 2 or lower than -2 residual values are considered equivalent to a significance level of 0.05 (Sharpe, 2015). The adjusted option was chosen because sample sizes in different levels vary substantially in some tables and the adjusted version takes account of these different sample sizes (Sharpe, 2015).

Where interval data is recorded *t*-tests were used to determine if there were statistically significant differences between the means in different groups. This is also reported in a similar way to previous studies (e.g. Alpert et al., 2000) for ease of comparison.

Research Question 3: Is there a 'power few' of pursuits and crashes amongst lead police drivers?

Question 3 is a separate question focusing on lead police drivers. A histogram was created first showing pursuit counts per lead police driver. The distribution was used to assess if a 'power few' (Sherman, 2007) of officers exists who engage in more pursuits relative to other officers who initiated fewer, but at least one pursuit. This was followed by analysis of the conditional probability of further pursuits per officer for each pursuit count, then analysis of whether more frequently pursuing officers' characteristics and outcomes differ depending on pursuit count per officer.

The pursuit count per officer was calculated using the SPSS aggregation function. This count was added to the original database as an additional variable. Regression was used to analyse speed differential because both variables, speed differential and pursuit count, were in interval form. For categorical variable analysis pursuit count data was pooled into two groups: 1 to 3 pursuits, and 4 or more pursuits. This split was selected as it was the closest possible division of the data to place half the total pursuits in each group. This split is considered a logical starting point for an exploratory study.

A limitation of the power few methodology applied here is that the time period extracted will cut off the count of pursuits initiated before 2011 and after 2014. It was not practicable to avoid this issue for this study, which will mean some officers with high pursuit counts over a wider time period or who changed workgroups were not placed in the higher pursuit count group, probably underestimating associations with pursuit count.

Conclusion

Variable selection has been informed by previous literature and matched with what is available in the New Zealand database. Data quality and missing variables will limit the study. However, the research design will identify patterns and concentrations of risk while addressing the three separate research questions with the data available.

Results

The results are outlined in this chapter beginning with Questions 1 and 2. The analyses start with an overview of descriptive statistics then follows the categories and variables identified in Figure 1: police variables, external variables, and fleeing vehicles and drivers. The chapter ends with Question 3, the results of the power few analysis.

The final cleaned dataset included 9,324 pursuit records entered into the database from 2011 to 2014 inclusive. However, the fleeing driver data is only available for drivers who were apprehended and identified (61.3%, 5717 pursuits). The crash percentage in the identified fleeing driver dataset is higher (16.9%, 967 pursuits) than the crash percentage in the total dataset (12.8%, 1190 pursuits).

Research Questions 1 and 2

Overview of New Zealand Pursuits

An overview of New Zealand pursuit outcomes is presented in Table 2. The total adds to more than 100% as a pursuit can have more than one outcome such as a crash and then an apprehension or abandonment. Crashes were reported during 12.8% (1190 pursuits) of pursuits and injury crashes were reported in 2.1% (199 pursuits) of pursuits. Seven fatal crashes occurred during pursuits, with a further 7 fatal crashes occurring shortly after abandonment. This means that for every pursuit initiated, there is a 1 in 666 chance of death occurring. No unrelated third parties or police officers died in these crashes. However, 18 uninvolved victims were seriously injured and 49 received minor injuries. In addition, 1 police officer was seriously injured and 37 received minor injuries. Officers abandoned 51.1% (4763 pursuits) of pursuits. Following abandonment 4.6% (430 pursuits) of pursuits resulted in crashes. Therefore, 17.4% (1620 pursuits) of pursuits ended in a crash during the pursuit or shortly after the pursuit was abandoned.

Table 2. *Overview of New Zealand pursuits 2011 to 2014*

Outcome	Number	Percentage of Pursuits
Fleeing Driver Identified	5717	61.3%
Pursuit Abandoned	4763	51.1%
Crash During Pursuit	1190	12.8%
Crash Post Pursuit	430	4.6%
Injury During Pursuit	199	2.1%
Injury Post Pursuit	103	1.1%
Fatal Crash During Pursuit	7	0.075%
Fatal Crash Post Pursuit	7	0.075%
Crash Deaths During or Post Pursuit	17	-
Total Pursuits	9324	100%

Figure 2 shows that New Zealand pursuits are often short with a high proportion lasting under two minutes (49.5%, 4563 pursuits). Twenty five percent (2322 pursuits) of pursuits are abandoned within 2 minutes of initiation.

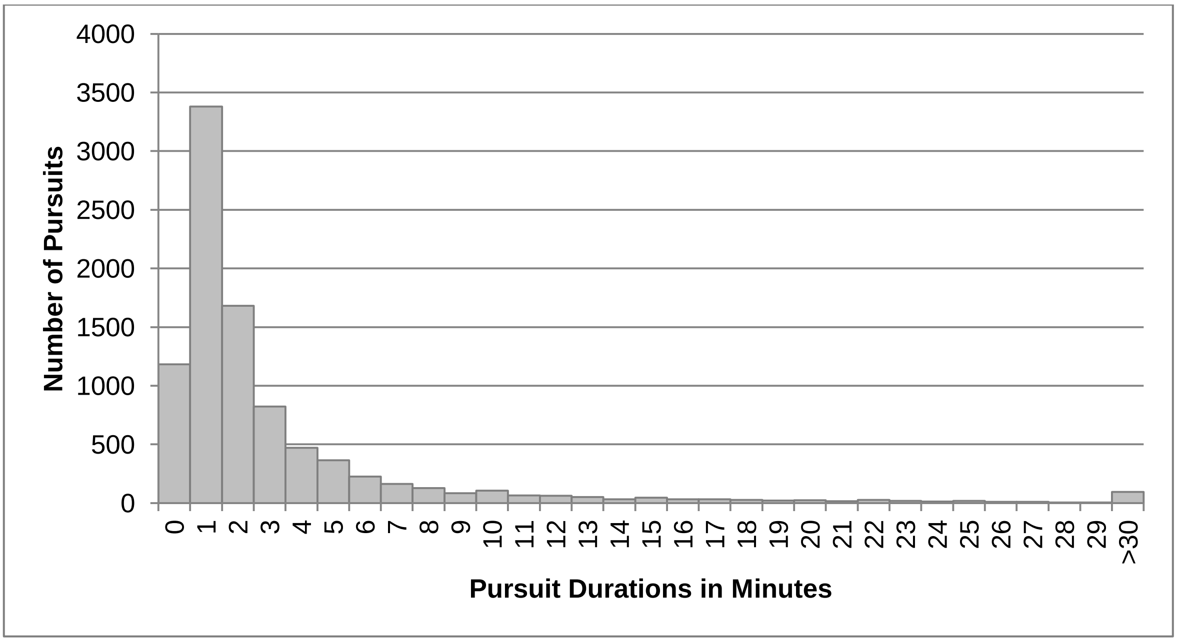

Figure 2. Pursuit durations in minutes (*N*=9227)

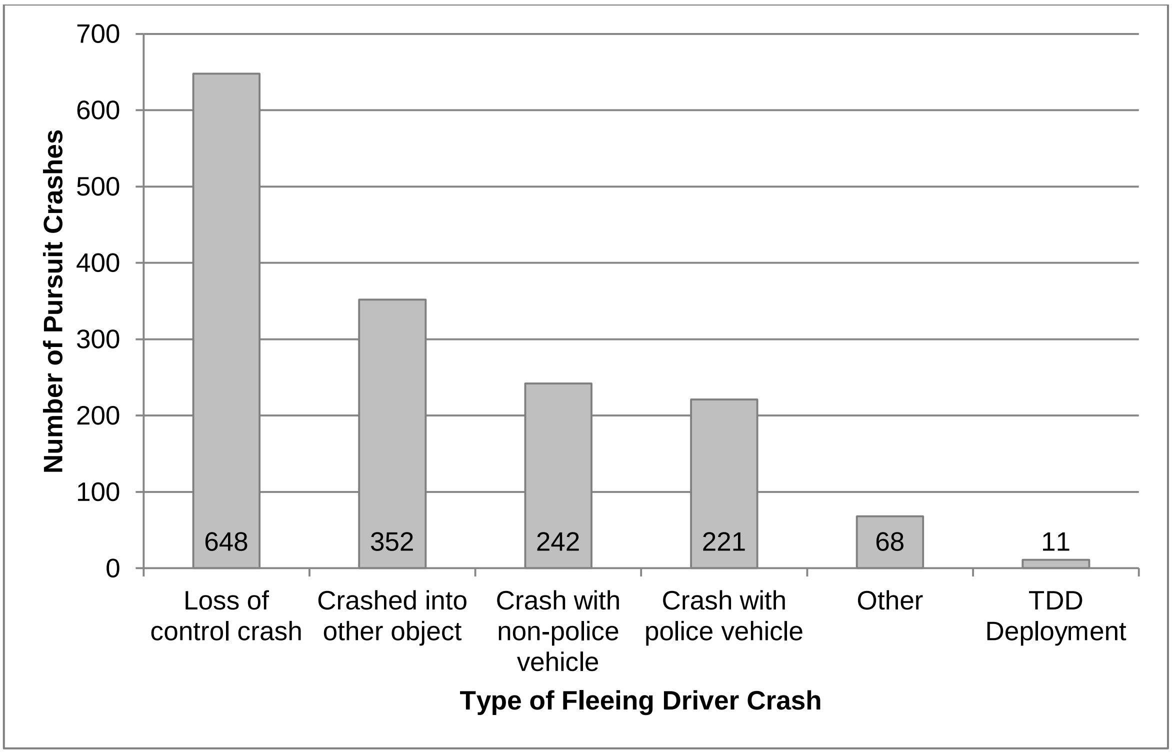

Figure 3. Number of pursuit crashes for each fleeing driver crash type (*N*=1542)

Figure 3 shows the types of crashes that occurred during or shortly after a pursuit (1542 pursuits). This is slightly lower than the figure in Table 2 (1620 pursuits) as there is only one crash type field and fleeing vehicles may occasionally crash several times during pursuit and after abandonment. The crash type selected by the officer for data entry may be inconsistent between multi-crash incidents. Most crashes occurred due to a loss of control or were into another object. A noteworthy proportion (30.0%), however, crashed into a non-police vehicle (242 pursuits) or police vehicle (221 pursuits). A small number of crashes (11 pursuits) were directly attributed to tyre deflation device (TDD) deployment.

Police Variables

Police have control over police variables operationally and in terms of training and policy. This section presents general descriptive statistics and analysis of concentrations and patterns of crash risk relating to the initial reason for vehicle stop, TDDs, air support, and officer demographics.

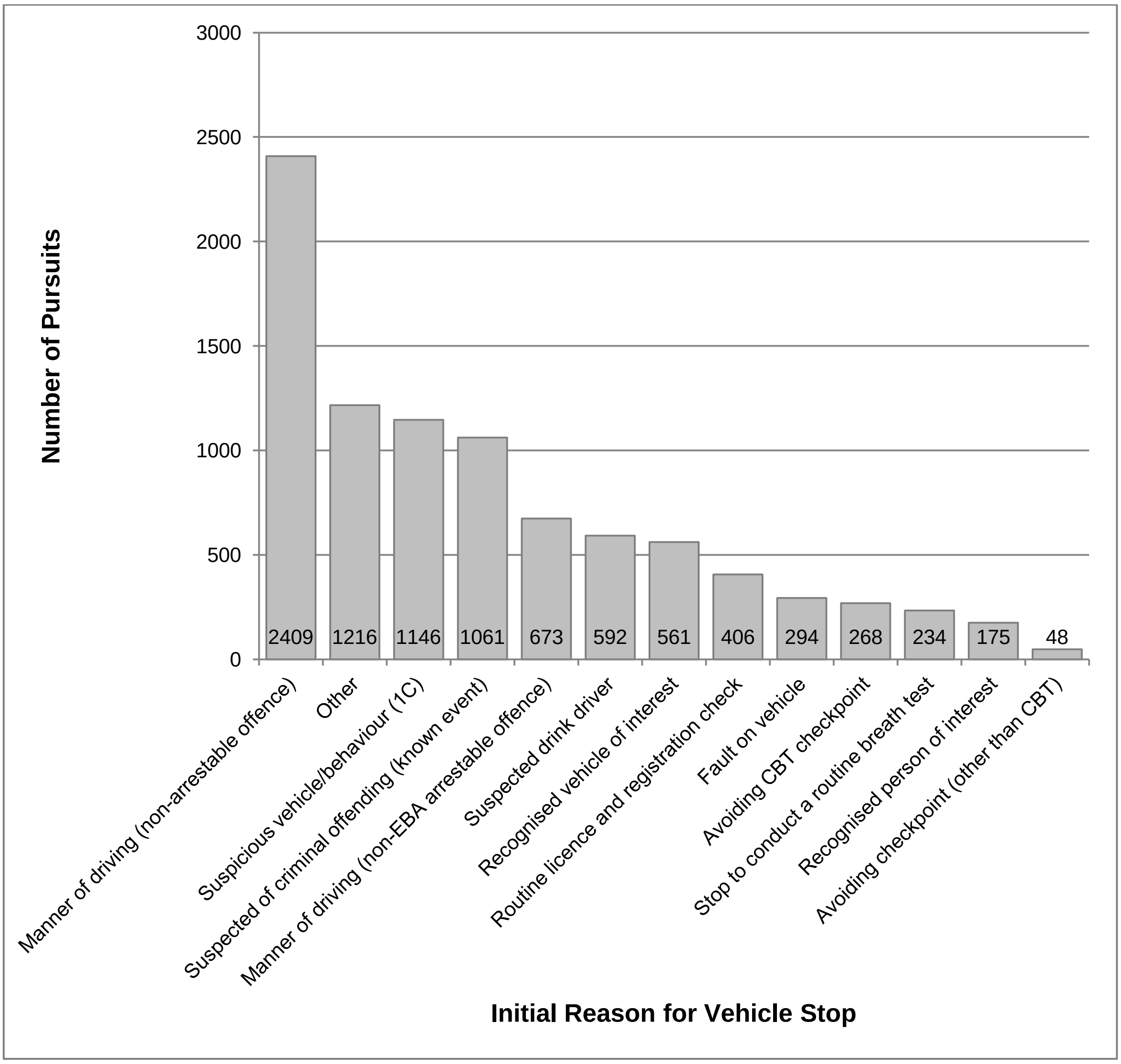

Figure 4. Number of pursuits for each initial reason for vehicle stop category (N=9083)

The initial reason for vehicle stops outlined in Figure 4 provides insight into the information officers apply when deciding to pursue. Many pursuits were initiated due to suspicion, non-arrestable driving offences or other traffic related offences including drink driving. There is no recorded variable specifying a serious crime or threat to life presented by the fleeing driver although some of these incidents might be recorded under Other, Suspected Criminal Offending, Recognised Person of Interest or Recognised Vehicle of Interest categories.

Table 3. *Cross-tabulation of initial reason for vehicle stop with no crash/crash*

Initial Reason for Vehicle Stop	**No Crash**	**Crash**	**Total**
Suspected Criminal Offending (Known Event)	854 (80.5%) *(-7.0)*	207 (19.5%) *(7.0)*	1061 (100%)
Suspected Drink Driver	484 (81.8%) *(-4.1)*	108 (18.2%) *(4.1)*	592 (100%)
Stop to Conduct Routine Breath Test	197 (84.2%) *(-1.4)*	37 (15.8%) *(1.4)*	234 (100%)
Avoiding Compulsory Breath Test Check Point	227 (84.7%) *(-1.2)*	41 (15.3%) *(1.2)*	268 (100%)
Recognised Vehicle of Interest	485 (86.5%) *(-0.6)*	76 (13.5%) *(0.6)*	561 (100%)
Avoiding a Checkpoint (Not Breath Test)	42 (87.5%) *(0.1)*	6 (12.5%) *(-0.1)*	48 (100%)
Suspicious Vehicle/Behaviour	1007 (87.9%) *(0.7)*	139 (12.1%) *(-0.7)*	1146 (100%)
Recognised Person of Interest	155 (88.6%) *(0.5)*	20 (11.4%) *(-0.5)*	175 (100%)
Other	1081 (89%) *(2.0)*	134 (11%) *(-2.0)*	1215 (100%)
Stop to Conduct Routine License and Registration Check	363 (89.4%) *(1.4)*	43 (10.6%) *(-1.4)*	406 (100%)
Manner of Driving (Non-Drink Driving Arrestable Offence)	602 (89.5%) *(1.8)*	71 (10.5%) *(-1.8)*	673 (100%)
Fault on Vehicle	263 (89.5%) *(1.2)*	31 (10.5%) *(-1.2)*	294 (100%)
Manner of Driving (Non-Arrestable)	2160 (89.7%) *(4.2)*	249 (10.3%) *(-4.2)*	2409 (100%
N =	7920	1162	9082

$\chi 2 = 85.670$ $df = 12$ $p < 0.001$ Cramer’s V = 0.097

Note. Adjusted standardised residuals appear in parentheses and italics below each group frequency.

Table 3 shows that a suspected criminal event involves the highest propensity to crash at 19.5% (207 crashes). This analysis attempts to somewhat replicate part of Alpert et al's (2000) United States' study, which found a BOLO (be on the look out) to be associated with high crash likelihood. Three levels in the initial reason for stop category broadly approximate a BOLO: Suspected Criminal Offending (Known Event), Recognised Vehicle of Interest, and Recognised Person of Interest. While the first level has the highest crash likelihood of 19.5% (207 crashes), the latter two level's crash likelihoods, 13.5% (76 crashes) and 11.4% (20 crashes) are much closer to the mean crash likelihood. The residual values indicate that of these three levels only the Suspected Criminal Offending group is significantly associated with crash likelihood. The odds ratio of a crash for the three BOLO type categories combined, compared to all other categories is 1.5.

Non-arrestable manner of driving offences have the lowest crash likelihood, but the highest pursuit count. The Suspected Drink Driver category has a significant residual (4.1) and a comparatively high crash percentage (18.2%).

Table 4. *Cross-tabulation of TDD not used/TDD used with no crash/crash*

	No Crash	Crash	Total
TDD Not Used	7650 (87.7%)	1076 (12.3%)	8726 (100%)
TDD Used	481 (80.8%)	114 (19.2%)	595 (100%)
N =	8131	1190	9321
$\chi 2 = 25.323$	$df = 1$	$p < 0.001$	Phi = 0.050

Table 4 presents a cross-tabulation of TDD used/TDD not used with no crash/crash. This shows that crash likelihood increased from 12.3% (1076 crashes) to 19.2% (114 crashes) when TDDs were deployed. The odds ratio for a crash when TDDs were used is 1.69. A chi-square test of association indicates that the relationship between the variables is statistically significant (p<0.001).

Although the use of TDDs is associated with crashes the evidence is less strong for injuries. A chi-square test of association indicated that there was no statistically significant relationship between injury rates when TDDs were not used (2.1%, 180 crashes) and TDDs used (3.2%, 19 crashes), $\chi^2(1, N=9321)=3.407$, $p=0.065$, which supports not rejecting the null hypothesis of no association at the 0.05 level. While it could be argued that the *p* value is close to the 0.05 level and significance level thresholds are arbitrary (Gardner and Altman, 1986) the large sample size should mean that notable effect sizes are detected at the 0.05 level which is why this is considered an appropriate significance level for this study.

Table 5. *Cross-tabulation of TDD not used/TDD used with driver not identified/driver identified*

	Driver Not Identified	**Driver Identified**	**Total**
TDD Not Used	3521 (40.4%)	5205 (59.6%)	8726 (100%)
TDD Used	93 (15.6%)	502 (84.4%)	595 (100%)
N =	3614	5707	9321
$\chi 2$ = 143.387	*df* = 1	*p* < 0.001	Phi = 0.124

Fleeing driver identifications are analysed for TDDs and air support to provide some balance and context to the assessment of crash risk as apprehensions are a key justification for their use. Offender identification is recorded in the database instead of apprehensions because pursuits are abandoned when drivers are identified and can be apprehended later. As Table 5 shows, there is a statistically significant association between TDD use and offender identification ($p<0.001$). This association indicates that TDD benefits are meaningful, increasing from 59.6% (5205 identifications) to 84.4% (502 identifications) when TDDs are used. The odds ratio is 3.65.

Table 6. *Cross-tabulation of air support not used/air support used with no crash/crash*

	No Crash	**Crash**	**Total**
Air Support Not Used	2146 (85.3%)	371 (14.7%)	2517(100%)
Air Support Used	499 (85.3%)	86 (14.7%)	585 (100%)
N =	2645	457	3102
$\chi 2 = 0.001$	*df* = 1	*p* = 0.981	Phi = 0.000

Table 6 only applies data from pursuits in the Waitamata, Auckland City and Counties/Manukau Districts (Auckland Metro) as these are the only Districts where the New Zealand Police Air Support Unit operates routinely. Table 6 shows that there is no statistically significant association between air support use and crash likelihood (p=0.981).

Table 7. *Cross-tabulation of air support used/air support not used with fleeing driver not identified/identified*

	Not Identified	**Identified**	**Total**
Air Support Not Used	1049 (41.7%)	1468 (58.3%)	2517 (100%)
Air Support Used	171 (29.2%)	414 (70.8%)	585 (100%)
N =	1220	1882	3102
$\chi 2 = 30.814$	*df* = 1	*p* < 0.001	Phi = 0.100

Table 7 also only applies Auckland Metro data and shows a notable increase in the likelihood of fleeing driver identification from 58.3% (1468 identified) where air support is not used to 70.8% (414 identified) where air support is used. A chi-square test of association indicates that the relationship is statistically significant (p<0.001).

Chi-square tests of association were also run on all categorical officer and police vehicle variables included in Figure 1. The results of chi-square tests showed that there were no statistically significant associations between any of these categorical variables and crash likelihood. These variables were gender, $\chi^2(1, N=8925)=0.24$, $p=0.876$, ethnicity $\chi^2(12, N=8925)=12.307$, $p=0.421$, police vehicle type, $\chi^2(3, N=9083)=1.602$, $p=0.659$, and Police Professional Driver Programme (PPDP) status, $\chi^2(3, N=9084)=7.072$, $p=0.70$.

Table 8. *Mean lead police driver age in no crash and crash groups*

	Number of Cases	Mean Age	Standard Deviation
No Crash	7781	36.96	8.82
Crash	1144	35.99	8.55
$t = 3.467$	$p < 0.001$		

An independent samples *t*-test was undertaken to analyse mean lead police driver age in crash and no crash groups. Levene's test for equality of variances indicated that homogeneity of variances could be assumed. Table 8 shows a statistically significant ($p<0.001$) difference of less than one year in mean age between groups.

Table 9. *Mean lead police driver service length in no crash and crash groups*

	Number of Cases	Mean Service Length	Standard Deviation
No Crash	7781	9.50	7.45
Crash	1144	8.94	7.18
$t = 2.360$	$p = 0.018$		

The *t*-test analysis of service length outlined in Table 9 also shows a small but statistically significant ($p=0.018$) difference in means in the crash and no crash groups. Levene's test for equality of variances indicated homogeneity of variances could be assumed. The difference in means could be a spurious result as age and service length are typically associated due to police agencies favouring recruitment of younger officers (Sherman, 1980). In any case, the association between both age and service length with crashes is small.

External Variables

Officers typically know the external variables at the time of pursuit. However, like fleeing driver variables, they usually have little control over them. This section outlines statistical analysis of time and day, Police District and road type.

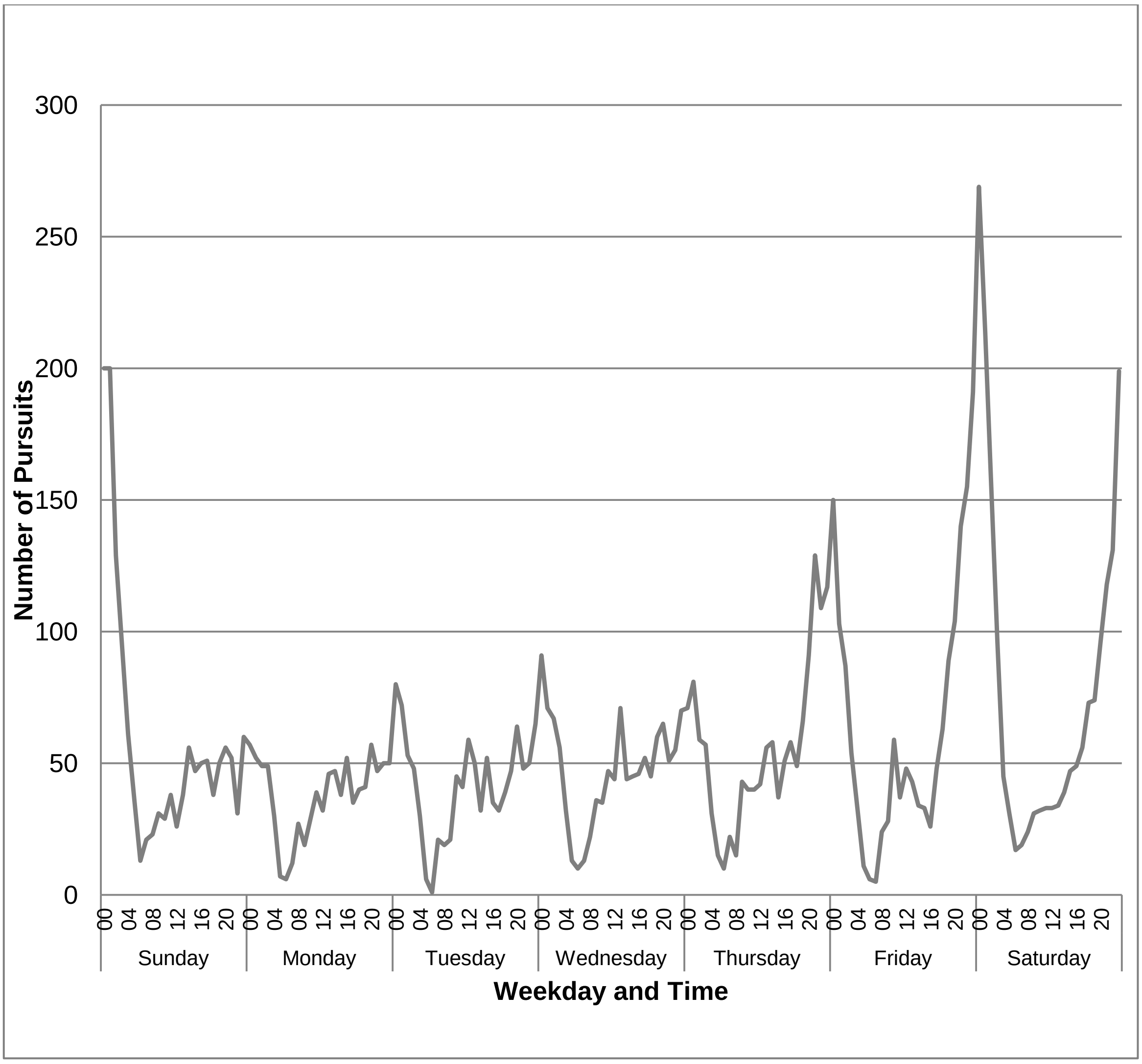

Figure 5. Number of pursuits on each weekday and time (*N*=9324)

Figure 5 shows the distribution of pursuits across time of day and day of week. The distribution mirrors the well-known temporal distribution of many crimes, which as Sherman (1992) notes generally cluster on weekends between 7pm and 3am. Concentrations of pursuits occur at night on Thursday, Friday and Saturday peaking at around midnight. More than five times as many pursuits occur at midnight on a Friday night than occur at midday on a Friday.

Unlike the agencies Sherman (1992) refers to that roster equal numbers of patrol staff on all shifts, New Zealand Police rosters double the number of patrol group staff on shift during peak demand periods between 10pm and either 1am, 2am or 3am on Thursday, Friday and Saturday nights where two shifts crossover. Additional specialist units like Traffic Alcohol Group also often work at these times. Reverse causation could therefore be involved in these peak pursuit counts. Reverse causation could occur because proactive policing outputs increase when more officers are working. As Figure 4 shows, many pursuits are initiated through proactive policing like traffic enforcement. Given the extent of the pursuits' concentration at night, however, it is unlikely that higher numbers of patrol staff on duty is the only explanation.

Table 10. *Cross-tabulation of day/night with no crash/crash*

	No Crash	Crash	Total
Day	3142 (88.5%)	409 (11.5%)	3551 (100%)
Night	4989 (86.5%)	781 (13.5%)	5770 (100%)
N =	8131	1190	9321
$\chi 2$ = 8.035	*df* =1	*p* = 0.005	Phi = 0.029

Table 10 shows the propensity to crash increasing from 11.5% (409 crashes) during the day to 13.5% (781 crashes) at night. Night is defined as between 8pm and 8am and day between 8am to 8pm. The odds ratio for a crash at night compared to daytime is 1.2, which is lower than other variables reported. This is a small difference, but combined with the very high concentration of pursuits at night the association between night and crash propensity becomes more noteworthy. A chi-square test of association indicates the relationship between variables is statistically significant (*p*=0.005). This small significant effect needs to be interpreted with some caution though due to the large sample size.

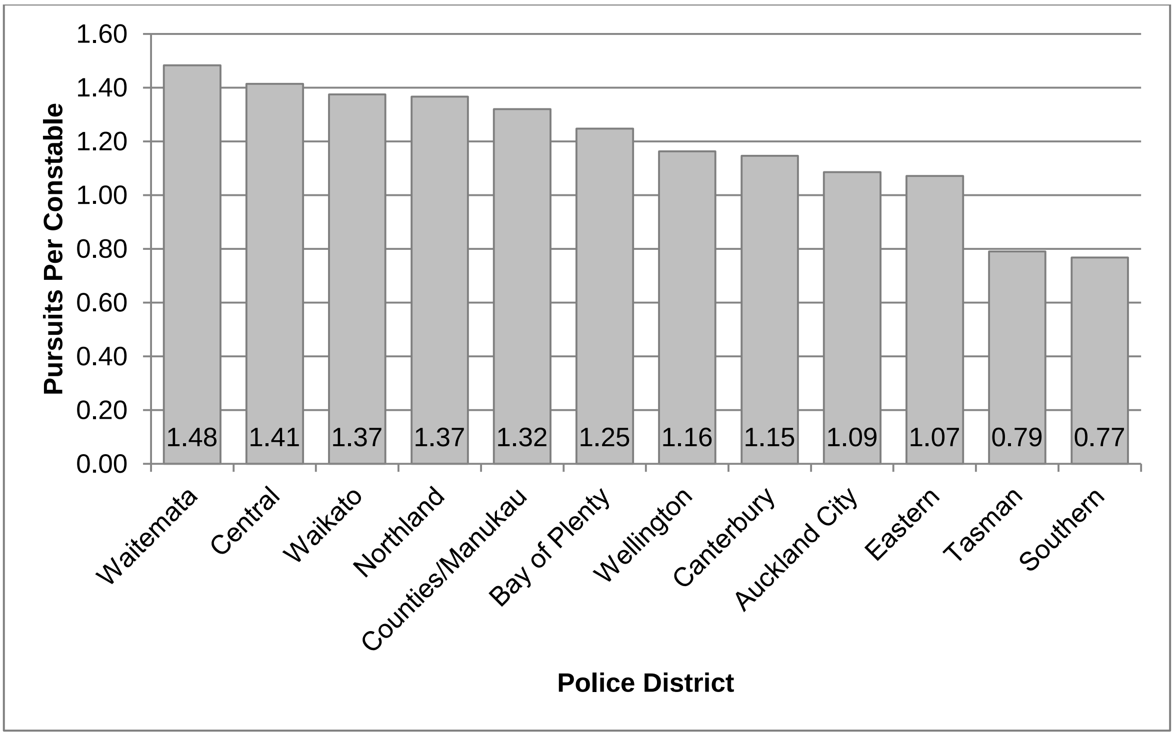

Figure 6. Number of pursuits per constabulary employee in each Police District (*N*=9324)

Figure 6 shows the number of pursuits per full time constabulary employee (2014 employee data) across each of the twelve New Zealand Police Districts. This indicates the relative level of exposure of officers to pursuits in each District, which varies considerably (map of New Zealand Police District boundaries located in Appendix 4, p.88).

Table 11 shows the likelihood of pursuit crashes that started in each of the twelve New Zealand Police Districts. Again, there is substantial variation between Districts. Propensity for constables to be exposed to pursuits is not matched with propensity for a pursuit crash. Eastern, a large rural District, has the highest crash likelihood whereas heavily populated and small Auckland City District is a close second. Auckland City's values explain more variance in the significant test result as evidenced by the residual value.

Table 11. *Cross-tabulation of Police District pursuit started with no crash/crash*

Police District	**No Crash**	**Crash**	**Total**
Eastern	362 (82.3%) *(-3.2)*	78 (17.7%) *(3.2)*	440 (100%)
Auckland City	711 (82.7%) *(-4.2)*	149 (17.3%) *(4.2)*	860 (100%)
Counties/Manukau	1132 (84.7%) *(-3.0)*	204 (15.3%) *(3.0)*	1336 (100%)
Bay of Plenty	720 (87.3%) *(0.0)*	105 (12.7%) *(0.0)*	825 (100%)
Waitemata	937 (87.5%) *(0.3)*	134 (12.5%) *(-0.3)*	1071 (100%)
Southern	373 (88.2%) *(0.6)*	50 (11.8%) *(-0.6)*	423 (100%)
Wellington	808 (88.3%) *(1.0)*	107 (11.7%) *(-1.0)*	915 (100%)
Canterbury	866 (88.8%) *(1.6)*	109 (11.2%) *(-1.6)*	975 (100%)
Central	845 (88.9%) *(1.7)*	105 (11.1%) *(-1.7)*	950 (100%)
Northland	392 (89.1%) *(1.2)*	48 (10.9%) *(-1.2)*	440 (100%)
Tasman	229 (90.5%) *(1.6)*	24 (9.5%) *(-1.6)*	253 (100%)
Waikato	756 (90.8%) *(3.2)*	77 (9.2%) *(-3.2)*	833 (100%)
N =	8131	1190	9321
$\chi 2 = 52.438$	$df = 11$	$p < 0.001$	Cramer's V = 0.075

Note. Adjusted standardised residuals appear in parentheses and italics below each group frequency.

Table 12 presents a cross-tabulation of three road types with no crash/crash. These road types were collated from reported speed limits. Rural/Highway roads have a lower crash propensity than arterial and urban roads. A chi-square test of association indicates that the relationship between road type and crashes is statistically significant (p<0.001), albeit the differences are small. Most pursuits occurred on urban roads where the crash likelihood is highest. The residual values indicate that rural/highway and urban explain most of the variance in the significant test result.

Table 12. *Cross-tabulation of road type with no crash/crash*

	No Crash	Crash	Total
Urban (<51kph)	4557 (86.0%) *(-4.1)*	742 (14.0%) *(4.1)*	5299 (100%)
Arterial (51-99kph)	964 (86.6%) *(-0.6)*	149 (13.4%) *(0.6)*	1113 (100%)
Rural/Highway (100kph)	2396 (89.9%) *(4.9)*	270 (10.1%) *(-4.9)*	2666 (100%)
N =	7918	1161	9079
$\chi 2 = 24.435$	$df = 3$	$p < 0.001$	Cramer's V = 0.052

Note. Adjusted standardised residuals appear in parentheses and italics below each group frequency.

Fleeing Vehicles

The first part of the analysis of offender variables is analysis of fleeing vehicles. Officers will often know this information during pursuits and can therefore use these findings to enhance their risk assessments. This analysis uses the full dataset rather than the subset used for the identified fleeing driver analysis that follows this section.

Table 13. *Cross-tabulation of not stolen/stolen with no crash/crash*

	No Crash	Crash	Total
Not Stolen	6399 (89.4%)	759 (10.6%)	7158 (100%)
Stolen	1498 (79.1%)	397 (20.9%)	1895 (100%)
N =	7987	1156	9053
$\chi 2 = 143.995$ $df = 1$	$p < 0.001$	Phi = 0.126	

Table 13 shows the cross-tabulation of not stolen/stolen with no crash/crash. The crash likelihood increases from 10.6% (759 pursuits) for vehicles that are not reported stolen to 20.9% (397 pursuits) for vehicles that are reported stolen. The odds ratio for a stolen vehicle crash is 2.23. A chi-square test of association indicated that the relationship between variables is statistically significant ($p<0.001$).

Table 14 shows a cross-tabulation of various vehicle types with crash likelihood. Trucks involve the highest crash percentage, although the pursuit numbers are very small and the residual (1.4) is not significant. SUVs, cars and utilities (pickup trucks) have similar, slightly above average crash likelihoods. However, only cars have a significant residual. Motorcycles have very low crash likelihoods with a comparatively high residual value (-7.9) indicating that it explains more variance in the significant test result than other variables.

Table 14. *Cross-tabulation of vehicle type with no crash/crash*

Vehicle Type	**No Crash**	**Crash**	**Total**
Truck	22 (78.6%) *(-1.4)*	6 (21.4%) *(1.4)*	28 (100%)
Other	60 (84.5%) *(-0.7)*	11 (15.5%) *(0.7)*	71 (100%)
SUV	347 (85.7%) *(-0.9)*	58 (14.3%) *(0.9)*	405 (100%)
Car	5480 (85.8%) *(-6.1)*	905 (14.2%) *(6.1)*	6385 (100%)
Utility	175 (85.8%) *(-0.6)*	29 (14.2%) *(0.6)*	204 (100%)
Van	128 (89.5%) *(0.9)*	15 (10.5%) *(-0.9)*	143 (100%)
Moped	81 (91.0%) *(1.1)*	8 (9.0%) *(-1.1)*	89 (100%
Motorcycle	1288 (93.7%) *(7.9)*	87 (6.3%) *(-7.9)*	1375 (100%)
N =	7581 (87.1%)	1119 (12.9%)	8700 (100%)
$\chi 2 = 67.477$	$df = 1$	$p < 0.001$	Cramer's V = 0.088

Note. Adjusted standardised residuals appear in parentheses and italics below each group frequency.

The mean crash percentage for this set of data is 12.9%. The slightly higher percentage than for the full database is due to the effect of missing data (624 pursuit records, 6.7%). A chi-square test of association indicates that the relationship between vehicle type and crashes is statistically significant (p<0.001).

Table 15 shows independent sample t-test results of differences in mean speed differential in no crash and crash groups. The speed differential was calculated by subtracting the pursuit's top speed from the road's speed limit. Levene's test for equality of variances indicated that homogeneity of variances could not be assumed. The t-test indicated that there was no statistically significant difference between the two group means (p=0.724). However, the differences in standard deviation and results from Levene's test indicate the possibility of some other differences in the data. There is also some possibility of officer under-reporting of this data. This result should therefore be interpreted with some caution.

Table 15. *Mean speed differential in no crash and crash groups*

	Number of Cases	**Mean Speed Differential**	**Standard Deviation**
No Crash	7908	40.38	26.73
Crash	1160	40.66	24.84
t = -0.354	p = 0.724		

Fleeing Drivers

This section presents descriptive fleeing driver analysis followed by an analysis of crash likelihood for each variable. These variables include age, ethnicity, licence and employment status. The 61.3% of pursuit records where fleeing drivers were identified are used for this analysis. These variables are least likely to be known by officers during pursuits.

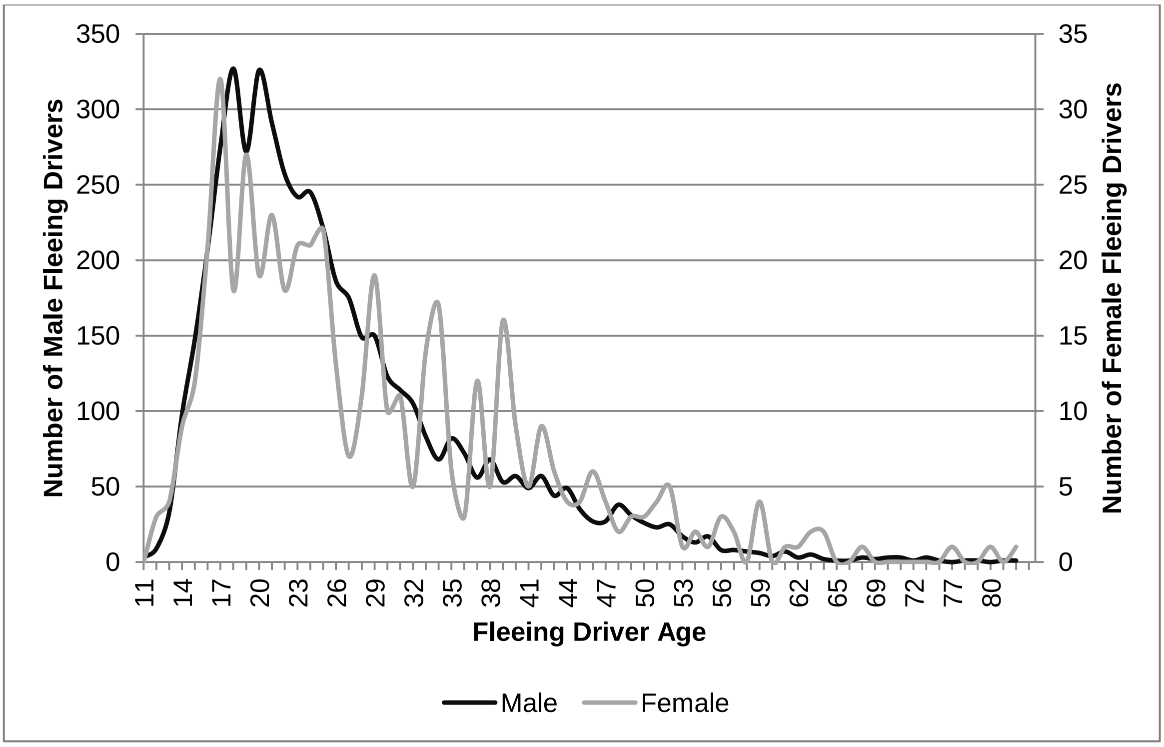

Figure 7. Age of male and female identified fleeing drivers (*N*=5533)

The majority of known fleeing drivers are males (91.2%, 5047 fleeing drivers) with a small percentage being female (8.8%, 486 fleeing drivers). Figure 7 presents the age-pursuit curves for males and females. These curves follow the pattern typically found in studies of age and crime peaking in late adolescence and then declining (Gottfredson and Hirschi, 1990). The youngest fleeing drivers were 11 years old (3 drivers). The oldest was 83 years old (1 driver). However, the final 18 years of age all recorded very low pursuit counts. There is a pronounced dip in the male curve at the age of 19, which could be due to random variation in the data or have an unknown cause. The mean age of identified fleeing drivers is 26.6 years (*SD*=10.4) and the median age is 24.0 years. Despite notable random variation in the female line a concentration in the younger age groups is still apparent.

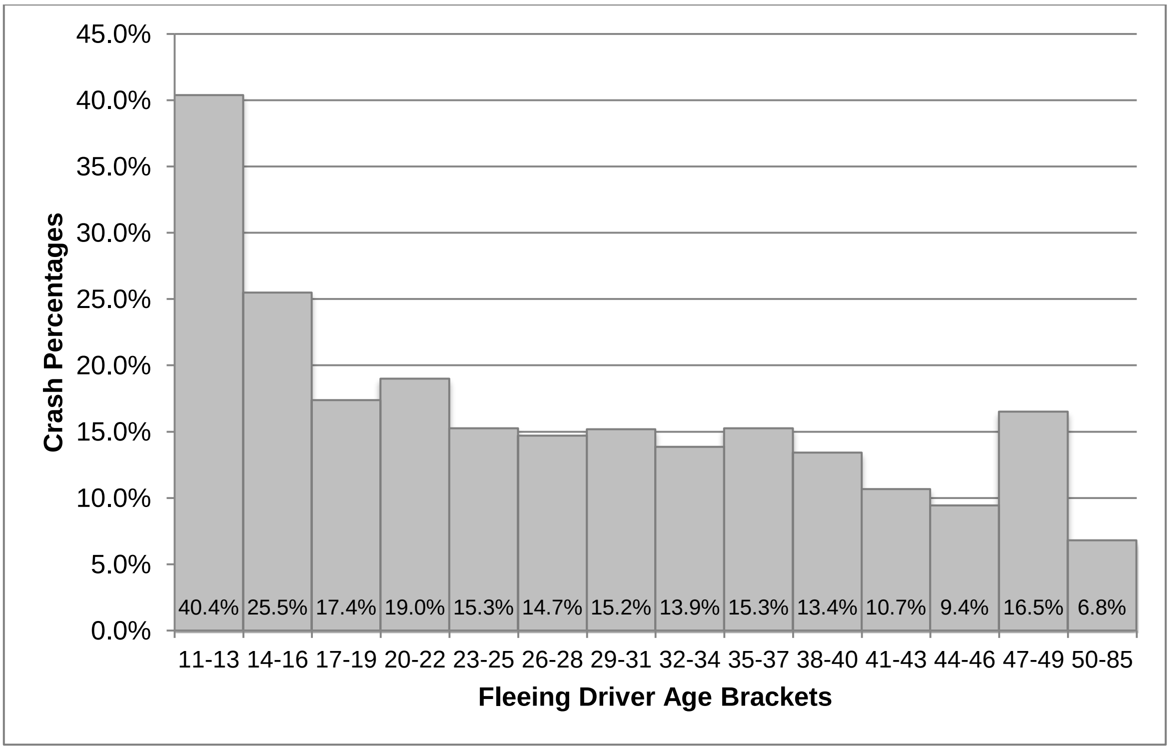

Figure 8. Identified fleeing driver age brackets and pursuit crash percentages (*N*=5708)

Figure 8 shows mean crash percentages by age bracket. The 11-13 group (considered children under New Zealand law) has the highest crash percentage (40.4%, 21 crashes). The 14-16 group (considered young people under New Zealand law) has the next highest crash percentage (25.5%, 130 crashes). The 17-19 (17.0%, 171 crashes) and 20-22 (19.0%, 183 crashes) groups also feature elevated crash percentages although not to the extent that the child and young person groups do.

Table 16. *Cross-tabulation of child or young person/adult with no crash/crash*

	No Crash	Crash	Total
Child or Young Person	411 (73.1%)	151 (26.9%)	562 (100%)
Adult	4344 (84.4%)	802 (15.6%)	5146 (100%)
N =	4755	953	5708
$\chi 2$ = 46.380	*df* =1	$p < 0.001$	Phi = -0.090

Table 16 shows a cross-tabulation of child or young person/adult with no crash/crash. Children and young people (26.9%, 151 crashes) have more than an 11 percentage point higher crash likelihood than adults (15.6%, 802 crashes). The odds ratio for a child or young person crash is 1.99. A chi-square test indicated that the relationship between variables is statistically significant ($p<0.001$).

Figure 9 presents the distribution of pursuits by age, with a comparison of whether the vehicle involved was reported stolen or not. This shows a peak of stolen vehicle pursuits at around the ages of 16 and 17 years before dropping sharply. The peak age for pursuits with vehicles that are not reported stolen is 20.

An independent samples *t*-test was conducted to compare mean ages in the stolen and not stolen groups. Levene's test for equality of variances indicated that homogeneity of variances could not be assumed. There was a statistically significant difference in mean ages between not stolen (M=27.85, SD=10.68) and stolen (M=22.14, SD=7.85); $t(2456.985)=20.526$, $p<0.001$.

Twenty one percent of pursuits involve a stolen vehicle. Forty nine per cent of stolen vehicle pursuits involved fleeing drivers aged 19 years or younger and 26.6% involved children and young people.

Table 17 shows that children and young people in stolen cars present a substantial risk of crashing relative to others with just under 1 in 3 (102, 32.4%) of the identified stolen group crashing during pursuits. Even taking account of the higher crash likelihood amongst identified fleeing drivers (16.9%) the crash likelihood for this group is considerably higher. The odds ratio for a stolen vehicle crash is 1.92, which means stolen vehicles driven by children and young people are somewhat close to twice as likely to crash as vehicles driven by children and young people that are not stolen. A chi-square test of association indicates that the relationship between variables is statistically significant ($p<0.001$).

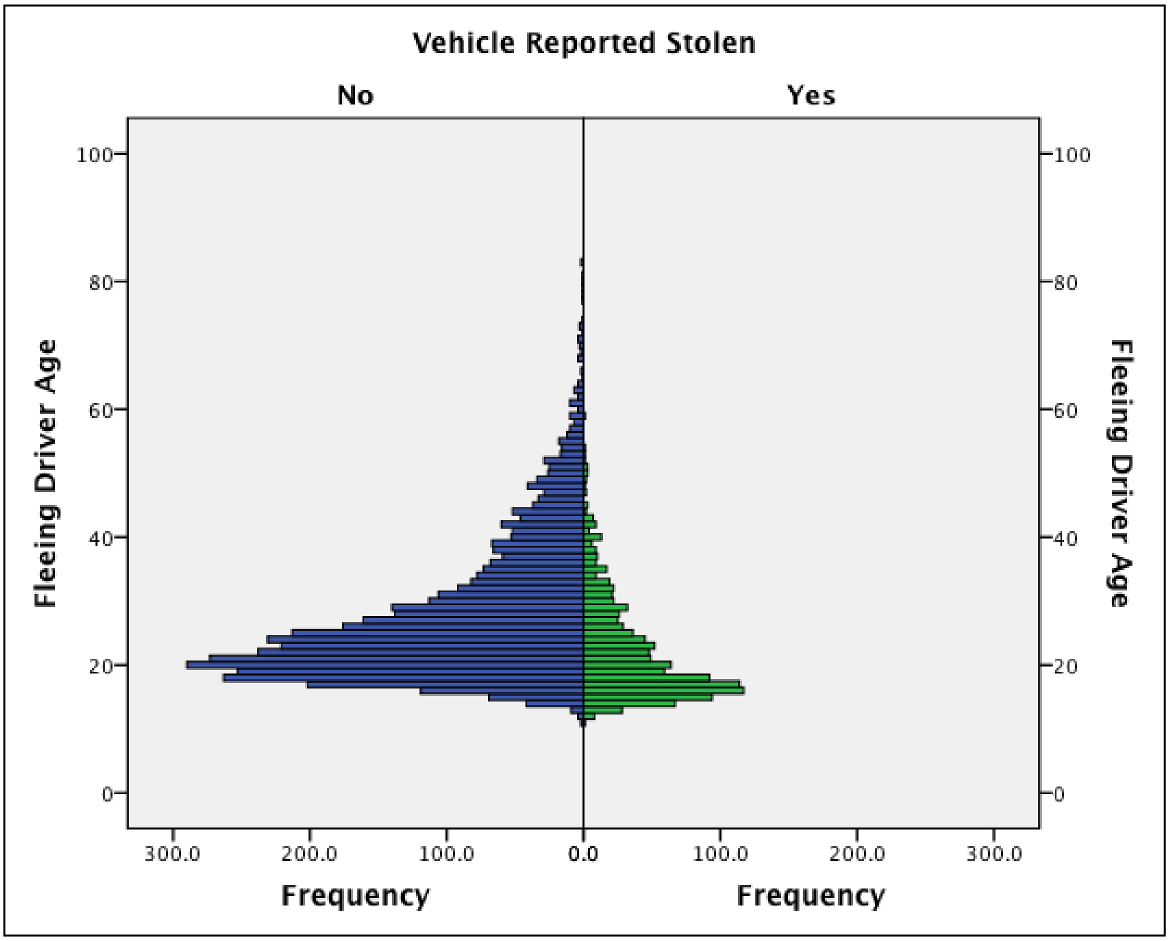

Figure 9. Identified fleeing driver age split by whether or not the pursued vehicle was stolen (*N*=5695)

Table 18 shows a cross-tabulation of ethnicity with no crash/crash. The European category includes New Zealanders of European descent and European citizens. This was unavoidable due to the way the data was originally collected. A chi-square test of association indicates that the relationship between ethnicity and crashes is statistically significant (p<0.001).

Table 17. *Cross-tabulation of not stolen/stolen with no crash/crash for children and young people only*

	No Crash	Crash	Total
Not Stolen	196 (80.0%)	49 (20.0%)	245 (100%)
Stolen	213 (67.6%)	102 (32.4%)	315 (100%)
N =	409	151	560
$\chi2$ = 10.727 df =1	p < 0.001		Phi = 0.138

The crash percentages of 20.6% (122 crashes) for Pacific Island and 19.2% (499 crashes) for Maori fleeing drivers present a notably higher crash risk than other groups. All residuals are higher than 2 or lower than -2 indicating that the differences between observed and expected values are considered unlikely to be due to chance. The odds ratio of Pacific Island and Maori known fleeing drivers combined, compared to all other ethnic groups is 1.55.

Table 18 . *Cross-tabulation of ethnicity with no crash/crash*

Ethnicity	**No Crash**	**Crash**	**Total**
Pacific Island	469 (79.4%) *(-2.6)*	122 (20.6%) *(2.6)*	591 (100%)
Maori	2095 (80.8%) *(-4.4)*	499 (19.2%) *(4.4)*	2594 (100%)
European	1970 (86.1%) *(4.9)*	317 (13.9%) *(-4.9)*	2287 (100%)
Other	220 (89.8%) *(2.8)*	25 (10.2%) *(-2.8)*	245 (100%)
N =	4754	963	5717
$\chi 2 = 38.932$	*df* = 3	$p < 0.001$	Cramer's V = 0.083

Note. Adjusted standardised residuals appear in parentheses and italics below each group frequency.

Table 19 shows the propensity to crash increasing from 12.3% (298 crashes) when the identified fleeing driver is licenced to 19.8% (652 crashes) where the fleeing driver is unlicenced. It also shows that the number of unlicenced drivers exceeds the number of licenced drivers. The odds ratio is 1.79. A chi-square test of association indicates that the relationship between groups is statistically significant (p<0.001).

Table 19. *Cross-tabulation of licenced/not licenced with no crash/crash*

	No Crash	Crash	Total
Licensed	2166 (87.7%)	298 (12.3%)	2414 (100%)
Not Licensed	2642 (80.2%)	652 (19.8%)	3294 (100%)
N =	4758	950	5708
$\chi 2$ = 55.716 *df* = 1	*p* < 0.001	Phi = -0.099	

Table 20 shows that the crash likelihood for employed fleeing drivers is lower at 14.2% (292 crashes) than fleeing drivers that are not employed at 18.7% (451 crashes). The odds ratio of known fleeing drivers who are employed compared to unemployed fleeing drivers is 1.39. A chi-square test of association indicates that the relationship between variables is statistically significant ($p<0.001$). While this is interesting, it is not unexpected and of the variables presented this is probably least likely to be known by officers.

Table 20. *Cross-tabulation of employed/not employed with no crash/crash*

	No Crash	Crash	Total
Employed	1767 (85.8%)	292 (14.2%)	2059 (100%)
Not Employed	1962 (81.3%)	451 (18.7%)	2413 (100%)
N =	3729	743	4472
$\chi 2$ = 16.302 *df* =1	*p* < 0.001	Phi = 0.060	

Research Question 3: Power Few Analysis

Question 3 aims to provide insight into the value of targeting specific officers for training, tracking or other administrative intervention where they are involved in more pursuits than other officers. In this section lead police drivers are the focus. The distribution of pursuit counts is presented first, followed by analysis of selected officer variables. Of the officers identified and anonymised, those who initiated more than three pursuits (19.8%, 718 officers) initiated 48.9% (4441 pursuits) of all pursuits. This group of lead police drivers was compared to officers who initiated 1 to 3 pursuits (51.1%, 4637 pursuits).

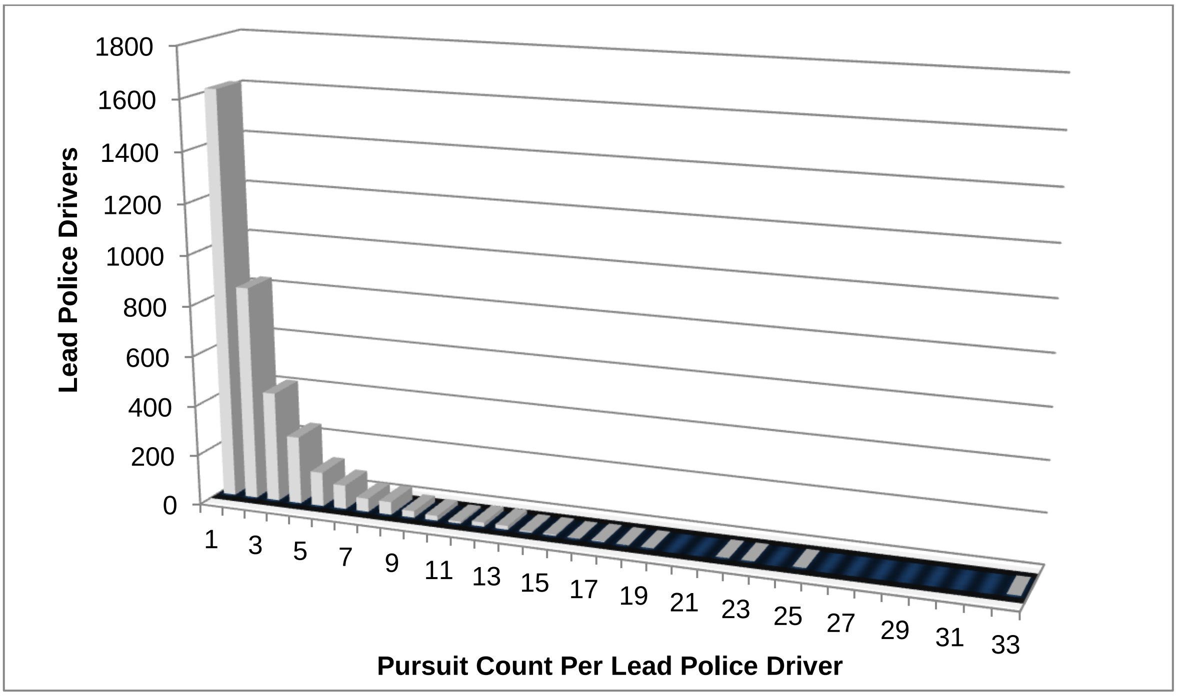

Figure 10. Number of lead police drivers in each pursuit count group 2011 to 2014 (*N*=3628)

Figure 10 illustrates the number of officers who were lead police driver in each pursuit count group (3628 officers). The range of pursuit counts per officer was 1 to 33. One officer initiated 33 pursuits. The next highest total was one officer who initiated 25 pursuits. The mode was one pursuit with 1620 (45.4%) officers initiating just one, 853 (23.5%) initiating two and 437 (12%) initiating three pursuits. The mean number of pursuits per lead police driver was 2.5 (*SD*=2.38) and the median was 2.

Figure 11 shows the conditional probability of a lead police driver having an additional pursuit. Probabilities are reported for each pursuit count up to 11 pursuits at which point the relationship became unstable due to small numbers in each group. This chart shows that the probability of initiating a further pursuit increases with each previous pursuit. This probability was calculated using pursuit frequencies, with the zero pursuit count group calculated from all constabulary employees (9068 officers in 2014). Some of these officers will not be exposed to pursuits due to their role. Therefore the actual analysis of lead police drivers starts at pursuit count group 1, not 0.

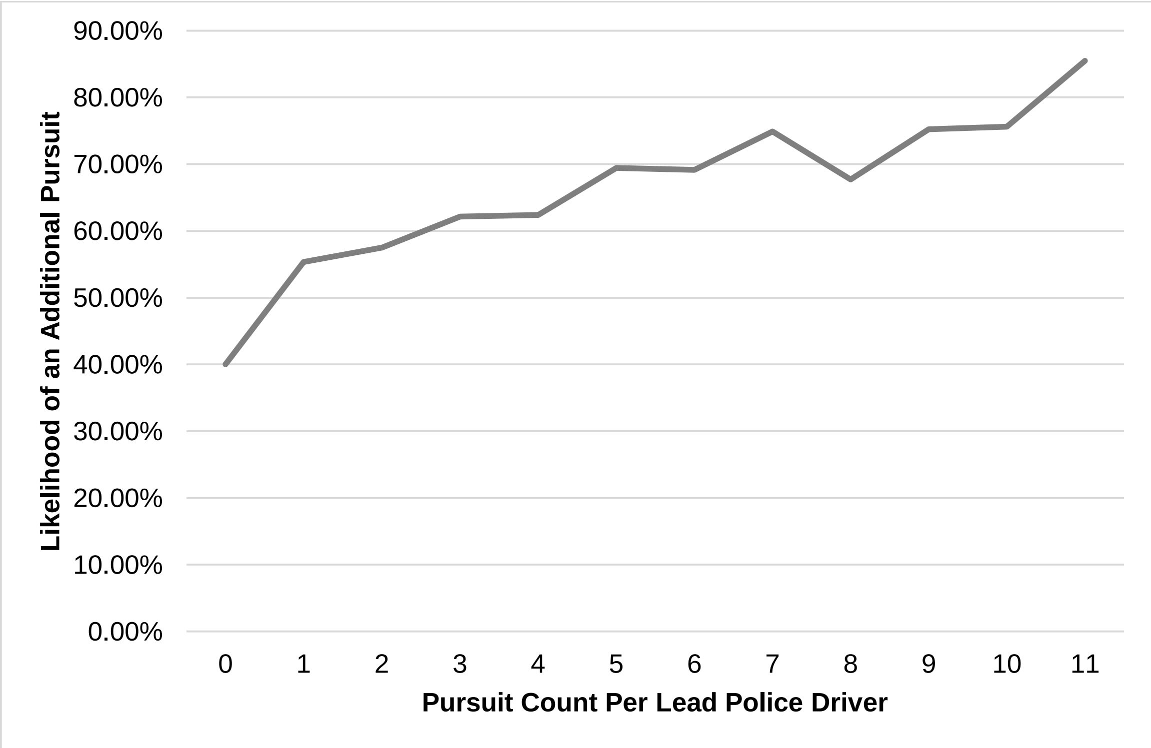

Figure 11. Conditional probability of an additional pursuit by a lead police driver in each pursuit count group

Variables and Pursuit Counts

Of all the officer demographic characteristics analysed in the present study none were strongly associated with crashes. However, Homant and Kennedy (1994) found that male officers, but no other officer demographic variables, were associated with preferring less restrictive pursuit policies in their United States study suggesting that gender might be a worthwhile area to explore further in relation to propensity to pursue. The proportion of female lead police drivers in the present study starts at 17.51% at one pursuit and decreases to below 5% of pursuits when the pursuit count exceeds 4 pursuits until the data becomes unstable from 11 pursuits. Females made up approximately 18% of all constabulary employees in 2014 (New Zealand Police, 2014).

Table 21 shows a cross-tabulation of gender and lead police drivers grouped into those who initiated 1 to 3 pursuits, or initiated 4 or more pursuits. The proportion of female lead police drivers involved in the 4 to 33 pursuit count group drops substantially compared to the 1 to 3 pursuit count group. The odds ratio is 4.64. A chi-square test of association indicates that the relationship between gender and pursuit count group is statistically significant ($p<0.001$).

Table 21. *Cross-tabulation of 1 to 3 pursuits/4 to 33 pursuits with female lead police drivers/male lead police drivers*

	Male	Female	Total
1 to 3 Pursuits	3963 (87.6%)	559 (12.4%)	4522 (100%)
4 to 33 Pursuits	4273 (97.0%)	130 (3.0%)	4403 (100%)
N =	8236	689	8925
$\chi 2 = 277.224$	$df = 1$	$p < 0.001$	Phi = 0.176

Mean speed differential was analysed due to the evidence of association between speed and crashes in the general population of road users (Aarts & Schagen, 2006). A linear regression established that pursuit count could statistically significantly predict mean speed differential, $F(1, N=9069)=57.703$, $p<0.001$. However pursuit count accounted for only 0.6% ($R^2=0.006$) of the explained variability in speed differential meaning in practical terms it is a very weak predictor. This association may only really be significant due to the large sample size.

Figure 12 shows no discernible trend in mean crash percentages for officers who initiated between one and ten pursuits (3566 officers). Random variation due to small numbers in the data is evident from a pursuit count of 11.

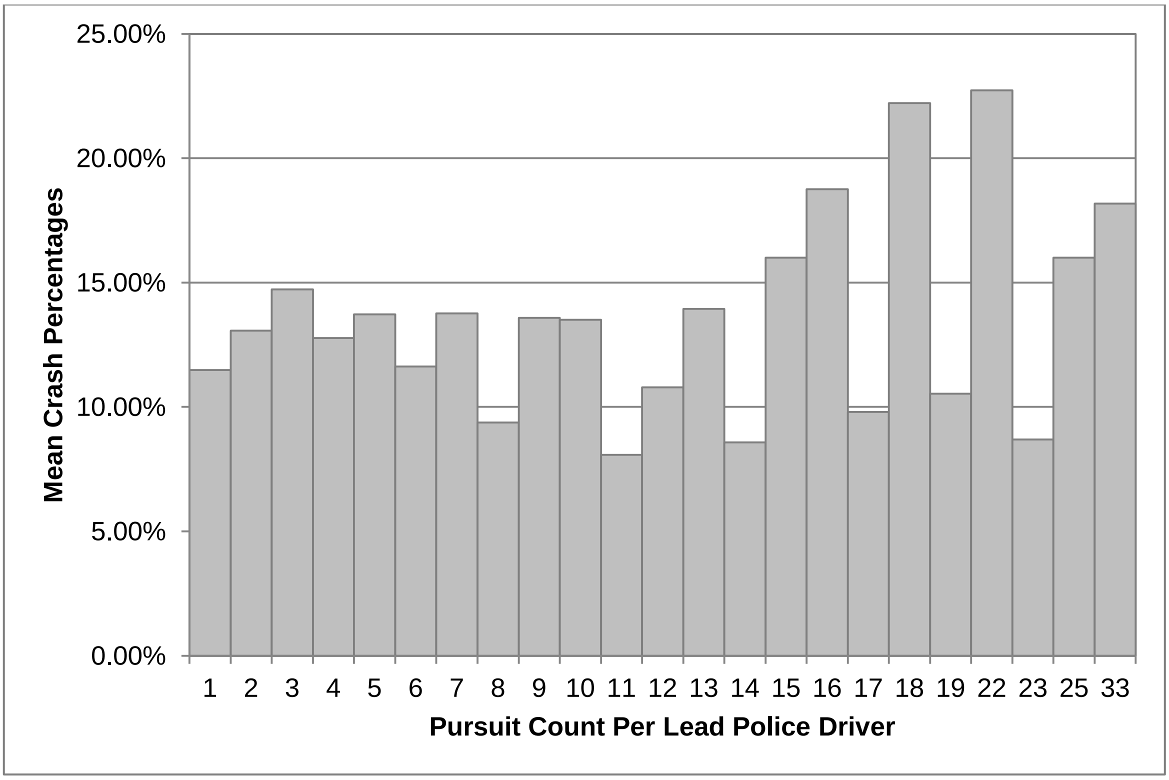

Figure 12. Mean crash percentages in each pursuit count per lead police driver group

Table 22 shows a cross-tabulation of 1 to 3 pursuits/4 to 33 pursuits groups, with no crash/crash. A chi-square test of association indicates that there is no statistically significant association between variables, (*p*=0.551).

Table 22. *Cross-tabulation of 1 to 3 pursuits/4 to 33 pursuits with no crash/crash*

	No Crash	Crash	Total
1 to 3 Pursuits	4035 (87.0%)	602 (13.0%)	4637 (100%)
4 to 33 Pursuits	3883 (87.4%)	558 (12.6%)	4441 (100%)
N =	7918	1160	9078
$\chi2$ = 0.355 *df* = 1	*p* = 0.551	Phi = -0.006	

A chi-square test of association was also undertaken of 1 to 3 pursuits/4 to 33 pursuits and fleeing driver identified/not identified and there was no statistically significant association, $\chi^2(1, N=9078)=0.204$, $p=0.651$. Likewise, abandoned/not abandoned pursuits were also not statistically significantly associated with pursuit count group, $\chi^2(1, N=9078)=0.767$, $p=0.381$.

Summary of Results

The results show that some variables associate strongly with crashes and are promising targets for crash prevention. The largest concentrations of crash likelihoods were found with stolen vehicles, young fleeing drivers and fleeing driver ethnicity. There were also temporal concentrations and concentrations of crash likelihoods in certain Police Districts. There were minimal significant associations found between police officer and vehicle variables, and crashes. However, other police variables, such as TDD use were associated with crashes, although perhaps not injuries. Air support was not associated with reduced crash likelihood, but was associated with increased offender identifications.

Results of the power few analyses were counter-intuitive. There are gender differences (outputs) between the characteristics of high and low pursuit count groups, but this does not translate into meaningful pursuit count and speed differential (outputs) associations or a significant association between pursuit count and crash likelihoods (outcome).

Discussion

This thesis set out to improve our empirical understanding of New Zealand pursuits by exploring general descriptive statistics, identifying concentrations and patterns of crash risk, and analysing whether a power few of officers exists in relation to pursuits and pursuit crash risk. Concentrations of crash likelihood did not always align with conventional wisdom. The limitations of intuitive judgement and conventional wisdom, and the potential benefits of empirical evidence have been commented on in relation to pursuits since the seminal pursuit studies of the 1980s (e.g. Alpert & Dunham, 1989). Discussion of how the results help our empirical understanding follows in this chapter along with a discussion of policy implications, study limitations and strengths, and recommendations for further research.

Main Findings

Overview

New Zealand pursuits are characterised by the very high proportion of abandoned pursuits (51.1%) and the comparatively low crash percentage (12.8%). These percentages are very different to previous studies where abandonment percentages were around 5% and average crash percentages across studies were around 30% (*SD*=10.5%) (as cited in Alpert and Lum, 2014). Despite different reporting rates across older studies, which could affect these percentages, this 30% figure is also similar to a contemporary (2011) California Highway Patrol report (as cited in Alpert & Lum, 2014) suggesting the figure is still indicative of at least some other jurisdictions' pursuit crash percentages. These findings provide some assurance that New Zealand is performing comparatively well with other jurisdictions that allow pursuits in regards to managing risk during pursuits.

Notwithstanding the benefits of the comparatively high-abandonment, low crash New Zealand model it is clear that some policy issues exist for New Zealand Police to consider. The initiation and abandonment of relatively large numbers of short pursuits highlights an obvious crash prevention opportunity. Almost half of pursuits are less than two minutes long and half of these are abandoned. Restricting or discouraging initiation of high-crash, low-benefit pursuit types in the first place seems a logical crash prevention approach if this can be implemented in a workable way. As pursuit benefits were not the focus of this study conclusions about pursuit value are somewhat cautiously drawn from analysis of crash likelihoods which was the study's focus.

Police Variables

TDD use is associated with higher fleeing driver identifications and pursuit crash likelihoods. However, the association with crashes might be misleading when viewed in isolation because TDDs are designed to lower vehicle speed and driver control, which would be expected to increase low-speed crash numbers. This is reflected in the lack of statistically significant association between TDD use and injuries, despite a significant increase in crashes. In any case, TDDs do not appear to be a panacea for risk mitigation. As Alpert and Lum (2014) pointed out, TDD use has not been properly evaluated for effectiveness compared to other pursuit tactics. Evidence of increased crash likelihood in this thesis indicates that TDDs are associated with risk. Alpert and Lum's (2014) view that robust evaluation evidence is needed to determine TDD effectiveness is therefore supported due to the association with crashes.

Targeting the deployment of operational officers with TDD capability to work at the peak pursuit times on Thursday, Friday and Saturday nights could be considered a logical response to concentrations of night time pursuits and should lead to increased apprehensions. This is also likely to increase the already slightly elevated pursuit crash risk at night, however. Deploying air support at these times is also likely to increase apprehensions.

Air support is not associated with reduced crash likelihood. This is surprising because the College of Policing (2015) stated that air support can reduce risk by allowing ground units to back off from fleeing drivers and Alpert (1998) also stated that air support can reduce risk. There are many possible explanations for this finding that need to be explored further. For example, air support will often not be nearby when pursuits start meaning that it is likely to be utilised more in longer pursuits and this might impact on relative crash likelihoods. Air support may also be more often deployed to what are considered higher risk pursuits. Air support may also simply not be being used in the best possible way to prevent crashes. Air support was associated with a useful increase in offender identifications. Consideration should be given to whether sufficient focus is being placed on using air support to prevent pursuit crashes. Assessment of how air support might best compliment pursuit avoidance tactics (see College of Policing, 2015) even if this involves forgoing some apprehensions may be a worthwhile approach to pursuit crash prevention.

As Alpert and Dunham (1989) note, the increased crash likelihood for BOLO related pursuits seems to result from these drivers fleeing more aggressively. This notion is supported by the New Zealand data, which also shows a higher crash likelihood when the fleeing driver is suspected of committing a crime (known event) although not categories involving more generic information about what officers are to look out for. Traffic stops were associated with the lowest crash risk in the present study and in Alpert et al's (2000) study, which also supports the view that wanted fleeing drivers are more likely to crash than other fleeing drivers such as traffic offenders. Drink driver related pursuits are also associated with higher crash likelihoods, probably due to alcohol impairment which can start to reduce driving skills at even low blood alcohol levels

(Moskowitz & Fiorentino, 2000). Impaired judgement and motivation to avoid prosecution may also play an important role in drink drive related pursuit crashes.

Where pursuit types relate to officer's looking for something or someone in particular they are by definition not spontaneous pursuits. Consideration should be given to how these pursuits might be avoided by not initiating the pursuit in the first place. Some examples of pursuit avoidance tactics include following the vehicle until it stops independently of police actions or following until a helicopter can track the vehicle without the need to initiate a ground pursuit (College of Policing, 2015). These tactics can be used when officers consider a pursuit very likely due to the information already held, as is the case in some drink driving and many BOLO-type vehicle stops.

Officer behaviour and outcomes across a range of policing activities were associated with demographic characteristics in previous studies (e.g. Sherman, 1980). Self-control theory (Gottfredson & Hirschi, 1990) has also been used as a framework for assessing police misconduct, with one study finding associations between low self-control and officer misconduct (Donner & Jennings, 2014). In regards to officer related crash propensity in the present study, the lack of statistically significant associations across officer gender, ethnicity, vehicle type and Police Professional Driver Programme (PPDP) status indicates consistency in crash likelihood across police vehicles and officers. The statistically significant differences in mean age and service length in crash and no crash groups were very small. This suggests that if low self-control and other unknown causal factors drive differences in officer behaviour as Donner and Jennings (2014), and Sherman (1980) outline, there is something mitigating these effects. Alpert et al's (2000) suggestion that training, oversight and administrative requirements lead to more consistent officer pursuit behaviour and outcomes as intuitive officer responses are replaced by a policy context might help explain the consistent crash likelihood across police variables in New

Zealand. If this explanation is accepted, the homogeneity of New Zealand police variables and crash risk is encouraging and suggestive of overall sound administrative oversight.

External Variables

Pursuit and pursuit crash concentrations at night are relevant to operational policy, especially when considered in the context of police variables like TDD and air support use. Officers might consider daytime pursuits to be more dangerous because of substantially increased pedestrian and traffic volumes. Alpert et al. (2000) found that daylight hours were associated with increased crash likelihoods. The evidence in the present study does not support this assessment, although the differences between day and night are small. Drink driving pursuits are likely to concentrate at night which might help explain the higher New Zealand pursuit crash risk at night. It might also be that risk posed by other road users during the day is currently compensated for by officers. The heavily pronounced concentration of pursuits on Thursday, Friday and Saturday nights amplify the importance of the otherwise small increase in night time crash risk to a level worth considering for risk management improvements.

Some Districts have higher pursuit numbers per constabulary employee and higher crash likelihoods than others. As each District has different crime profiles and geography this comes as no surprise. The evident differences in crash likelihood on different road types also probably play a role in District crash likelihood differences.

Fleeing Vehicles and Drivers

Different vehicle types were associated with different crash likelihoods. Motorcycles had much lower crash likelihoods (6.3%) than other vehicles. This is possibly a reflection of police risk management as motorcycles are recognised as posing an especially high risk of injury and death (New Zealand Police, 2003), or motorcycles might more easily escape from police. Fleeing motorcycle pursuits have a higher abandonment percentage of 66.8% (918 pursuits) than the abandonment percentage for all pursuits (51.1%, 4763 pursuits). Higher abandonments could be affected by police risk-aversion or motorcycles escaping.

The most obvious and pronounced concentration of fleeing driver pursuit harm per pursuit is posed by children and young people. Young adults up to the age of about 22 also have higher than average crash percentages. Apprehension and charge data is needed to be sure about pursuit benefits for these groups. It is nevertheless difficult to reconcile how the substantially elevated crash risk (almost double) and the ever-present risk of injury and death are justified for the vast majority of offending committed by children and young people. We know that many of these offenders will age out of crime (Bottoms, 2010; 2014) and many young offenders commit relatively minor offences. Only 6% (204 young people) of all young people arrested in 2010 were convicted and then sentenced and most of these received a community sentence (Ministry of Justice, 2010). All others were dealt with in an alternative way, such as a family group conference (restorative justice). This suggests that pursuits risking life and property to the extent reported in the present study are very unlikely to be objectively justified in order to attain the vast majority of judicial outcomes for children and young people. It is acknowledged that allowing these drivers to continue without police intervention is not without its risks. However, as Hoffman and Mazerolle (2005) state, pursuits can lead to a greater danger than the original offence.

Of course, it is valid to argue that pursuing officers often do not know the fleeing driver's age or other characteristics. The reality is that officers sometimes know these details and other times they do not. Patrol Officers as 'street-level bureaucrats' (Alpert & Dunham, 1989) are well versed in making decisions in the context of bounded rationality.

Bounded rationality refers to making decisions within information and cognitive limitations (see Rumelt, Schendel & Teece., 1994 for further explanation). As Boston et al. (1996) note, the higher the level of bounded rationality, which is increased by limitations of information availability and complexity, the higher the chance of failure. Increasing information availability is therefore important for decreasing the risk of operational failure.

The association between stolen vehicles and child, young person and young adult pursuits can be used to increase information availability and therefore reduce the risk of operational failure. Unlike fleeing driver age, stolen vehicle status is often known by pursuing officers. Stolen vehicles are around twice as likely to crash and more likely to involve a child, young person, or young adult behind the wheel. When pursued stolen vehicles are driven by children and young people almost one in three pursuits involve a crash. Consideration of whether stolen vehicle, and child and young person pursuits should be discouraged or restricted, as has been the case in Tasmania, Australia (Hoffman, 2003) for example, seems to be a promising approach for pursuit crash prevention.

One apparently counter-intuitive finding from this study is that mean speed differential does not appear to be associated with crashes. Given that we know speed is associated with traffic crashes in the general population of road users (Ministry of Transport, 2014b, Aarts & Schagen, 2006) this result seems out of place. Under-reporting of speed might be involved as might current pursuit management approaches. Previous studies (e.g. Senese & Lucadamo, 1996) found that speed did not predict pursuit crashes, whereas other studies found that speed was associated with crashes (e.g. Alpert et al., 2000; Wade, 2015).

Power Few Analysis

The power few analysis considered several variables by using lead police drivers and their pursuit counts as the focus. Gender (input) was associated with different pursuit count groups. Speed differential was only very weakly associated with pursuit count groups. Most importantly crashes, offender identification, and abandonments (outcomes) were not associated with pursuit count groups. Administrative oversight might homogenise risks associated with officer pursuit count (Alpert et al., 2000) or pursuit count might simply not predict crashes for other reasons. This means that any increased targeting of more frequently pursuing officers in regards to policy, oversight and training may only prevent additional harm relative to the officers' higher pursuit count concentration.

As several different variables have been highlighted as promising harm prevention targets it is worthwhile to briefly consider an approach to implementing any pursuit policy changes. Thaler and Sunstein (2009) argue that setting default options for choices is very important because default options are often chosen, especially when decisions are complex, regardless of the facts available. The high number of pursuits initiated and abandoned in New Zealand indicates a default position for officers to pursue then assess risk. An alternative policy would reverse the default position to not initiating a pursuit in the first place unless specific justifying facts were already known. This policy type has been implemented by Milwaukee Police (USA), for example, which requires a violent felony to be a known factor prior to initiating pursuit (Alpert & Lum, 2014). In New Zealand useful prior knowledge requirements could be that the driver is not a child or young person or the car is not reported stolen.

Theory

There is currently no theory of pursuits that attempts to explain this offending or that could be tested empirically. As pursuits often involve other criminality, such as a stolen vehicle or fleeing from another crime, existing theory can provide insights into pursuit incidents. Desistance and deterrence theories appear most relevant to pursuits.

The age-pursuit curve follows the well-established age-crime curve pattern including the dominance of males in this offending (Gottfredson & Hirschi, 1990; Bottoms, 2010; 2014). The distribution of fleeing driver offending with its concentration in late adolescence and decline in their late twenties and early thirties provides further evidence of the durability of this association between offending and age across crime types and contexts. Gottfredson and Hirschi (1990) suggest that age and traffic crashes follow similar patterns to crime beginning at high rates when drivers are old enough to drive and then dropping rapidly in early adulthood. The distribution of pursuit crashes follows this pattern except that the youngest fleeing drivers are not old enough to drive legally.

Pursuits and pursuit crash likelihoods are concentrated in young ages, primarily children (up to 13 years) and young people (14 to 16 inclusive). These results are consistent with many theories of desistance. As Bottoms (2014) notes, desistance research is still growing. However, given the evident patterns of pursuit offending and age, and the durability of this relationship across crime types, it appears useful to apply theories of desistance to pursuits.

The peaks in the male age-pursuit curve at the ages of 18 and 20 appear noteworthy. These peaks could be due to random variation in the data, although they are quite pronounced relative to other variations. The 18 year peak coincides with the peak age for stolen vehicle pursuits, whereas the 20 year peak coincides with not stolen vehicle pursuits. This could be due to chance or be part of an explanation for the shape of the male age-pursuit curve.

Highlighting areas of pursuit crash risk has led to harm reduction suggestions that involve restrictive or discouraging policies such as not pursuing children and young people. Deterrence is often used as an argument against restrictive and discouraging pursuit policies (Alpert & Dunham, 1989; Alpert et al., 2000). While several authors have expressed scepticism at the level to which deterrence theory applies to pursuits or that crime rates would increase if pursuits were restricted or discouraged (e.g. Beckham, 1983; Fyfe, 1990; Alpert and Lum, 2014) robust testing of the theory that pursuits deter traffic or criminal offending remains a gap. Nagin (1998) notes that the evidence for longer-term deterrence across all crimes is not clear and there is still a lot we do not know about deterrence and risk perceptions from offenders. The evidence of traffic policing's deterrent effect is stronger (see Zaal, 1994 for example), but the unique characteristics of pursuit and the cross-over with criminal offending complicate the assessment of deterrence and pursuits. Any policy restricting or discouraging pursuits should therefore be implemented with some caution of potential reduced deterrent effects, given that robust evidence does not exist about its effect either way.

Analysis of whether a power few concentration of risk in the population of officers exposed to pursuits reported useful results. Sherman (2007) stated that focusing resources where the most harm concentrates will maximise harm reduction for programmes that are effective. A concentration of pursuits among officers does exist. Around 20% of officers having at least one pursuit accounted for around 50% of pursuits. Male officers were also more likely to have a higher pursuit count than female officers, which is consistent with Kennedy's (1994) finding that male officers had more positive attitudes towards pursuit. There does not appear to be a 'power few' of officers associated with pursuit crash likelihoods per pursuit and pursuit counts, however. Higher pursuit counts could be influenced by officers' exposure to fleeing drivers in their location or role and there is no evidence of increased pursuit count being associated with increased crash likelihood, or any outcome, per pursuit.

It is evident therefore that much remains to be developed in relation to pursuits and theory. This thesis does not specifically address the theoretical framework for pursuits. It does, however, highlight some patterns and concentrations of risk that may be useful for theoretical development and application of existing criminological theory to pursuits.

Study Limitations

The research design used is a Level 1 study on the Maryland Scale of Scientific Methods (for further explanation, see Sherman et al., 1998). This type of study cannot provide robust evidence of causation because the design does not control for rival causal factors (Gosling, 1995). It is, however, a useful approach to identify promising areas to target harm prevention and tracking of police activities (Sherman, 1992). This was the first study of its type in New Zealand and was hampered by the database not being set up for research and by missing data.

As an administrative database was used there are inevitably a number of research limitations. Omitted variables due to the data not being collected in the first place were a substantial limitation on the scope of this study. Variables such as weather, urban/rural splits and traffic conditions were identified as important variables in other studies (e.g. Alpert & Dunham, 1989; Homel, 1994, Alpert et al., 2000). Adding these variables to the New Zealand database would enhance future research. There were at least ten variables identified as being likely to be useful for analysis that were not available in the database. Some, such as weather, are highly likely to be associated with pursuit crashes and other pursuit outcomes. Identities of police who join pursuits and officer work groups were not identified in previous studies. However, these data would allow expansion of future research into other dimensions of pursuit including more detailed power few analysis.

Remedying data quality problems absorbed substantial researcher time and not all measurement issues could be resolved. Another option would be to have randomly selected a sample that could then have been more thoroughly cleaned. This approach would have improved measurement validity, although at the expense of statistical power.

Study Strengths

While the analysis attempted to replicate previous research in terms of variables analysed, statistical analysis and presentation the results were not always consistent with prior research or with conventional wisdom. These findings support Sherman's (2013) assertion of the importance of conducting research in different jurisdictions and the limitations of relying on generalisations from research in other countries.

Some of the findings provide a new and unique contribution to the literature on pursuits. For example, the lack of association between air support and crashes is contrary to academic (Alpert, 1989) and practitioner-related views (e.g. College of Policing, 2015). Findings of crash risk associations with age and stolen vehicle status are not unique in an international sense, but are in New Zealand academic research. The findings also establish a basis for further research to build a New Zealand pursuits evidence base.

Most previous studies applied data from state or local police agencies. Data collection variations limit comparisons between studies (Alpert & Lum, 2014). Use of nationwide data in the present study is therefore an advantage as is the high reporting rate that came about through the use of an electronic reporting system in New Zealand. The database size and number of variables available was a clear strength notwithstanding that some useful variables were missing. The database provided a useful opportunity to consider risk given that it was set up for accountability processes not research. Selection bias was not relevant due to already having very close to a total dataset of pursuits for the timeframe extracted (although other biases do apply).

The power few analysis entered uncharted territory in relation to pursuits research internationally. The finding of no association between officers who engage in larger numbers of pursuits, and crashes (or any outcome) was unexpected. This result was encouraging though as gender differences indicated that the groups were different, but this did not translate into significantly different crash likelihoods. This finding might be indicative of sound administrative oversight in New Zealand.

Further Research

As the first descriptive study exploring the database the analysis tried to make sense of the data at hand. The analysis could only be taken so far within fixed time constraints. Now that there is a clearer understanding of at least some variables associated with pursuit crashes it is useful to consider what else could be done with the available data, or with an improved database.

Speed differential did not have statistically significantly different means in crash and no crash groups. However, there could be some other underlying difference in the data as evidenced by the different standard deviations for each group. Further research, perhaps pooling the variable into categories and conducting chi-square analysis may provide further insights into the nature of speed differential and crash-risk.

Ethnicity featured in crash likelihood concentrations. Integrating this finding into operational policing is complex due to ethical issues. Further research into associations with the reason for pursuit, abandonments and charges following pursuits would inform policy development and better highlight whether police can do anything practical to reduce the concentrations of crash likelihood among Maori and Pacific Island fleeing drivers.

The present study goes some way to identify areas where harm concentrates. What is missing of course is a comprehensive analysis of pursuit benefits, which do exist (Alpert et al., 2000). It would be beneficial therefore for New Zealand Police to link criminal charge data to pursuit database records as is already the case in use of force reports. This would allow for the comparison between costs (crashes) and benefits (apprehensions) as has already been attempted elsewhere (e.g. Crew & Hart, 1999). Application of a crime harm index (Sherman, Neyroud & Neyroud, 2014) and collision harm index (e.g. Lawes, 2014) may then be integrated into subsequent analysis to quantify costs and benefits.

While this enhanced data is not currently available it would be possible to complete more extensive bivariate analysis of variables such as age and stolen vehicle status with binary outcome analysis of offenders identified or pursuits abandoned. The existing database could also be used to explore differences in crash likelihoods after pursuits are abandoned. Post abandonment analysis would be enhanced by the addition of other relevant variables, but a useful study could be undertaken with the existing data only.

Multivariate techniques would also extend our knowledge of the collective relationship between variables and various outcomes. Alpert et al. (2000) used discriminant analysis to identify which variables predict pursuit outcomes. This might be a useful way of assessing the collective predictive value of the New Zealand variables. Multivariate logistic regression is another option to ascertain factors that best predict crash involvement. Olphin (2014) used this technique to analyse solvability factors in his study and a similar approach could be taken with pursuit crashes, apprehensions or abandonments as a dichotomous dependent variable. Random forest modelling is another option for future multivariate research. This technique can be used as a forecasting tool to predict risk (e.g. Barnes & Hyatt, 2012). Omitted variables, missing data and data quality will continue to limit any of these approaches, however, which is further reason to improve data quality and database design.

The power few analysis was also limited, especially because it was not practicable to apply all officers' pursuit counts. It would be useful to expand on this approach by tracking officers over time to see if individual officers' outcomes changed with additional pursuits in a longitudinal study. Replacing free text fields for officer details with a drop-down menu of officer numbers would make this type of research much more feasible. Given the notable differences in crash likelihood in each District, research looking at whether crash risk per officer varies across Districts might also prove useful.

Alpert and Lum (2014) point out that there has been no rigorous evaluation of policy effects on any pursuit outcomes and none were identified in the present study's literature review. Any rigorous evaluation would be difficult to conduct; especially a randomised controlled trial due to ethical issues randomising pursuits. However, a quasi-experimental approach may be possible, perhaps along the lines of Fyfe's (1979) evaluation of New York police shootings policy reforms. Barriers to even this type of research are numerous such as enhanced reporting that often accompanies reform, which alters datasets across time periods and makes comparisons more difficult.

External Validity

Because New Zealand has one national police service with a nationwide database the findings from this study are useful for considering the national picture. However, there are 12 Police Districts that are all very different. Some are small and heavily urbanised whereas others are very large and almost entirely rural. The ability to generalise findings to Police District level from the national level is therefore limited by context variations. Generalising findings to other policing jurisdictions always has limitations (Sherman, 2013). However, where findings support other research they can perhaps be more confidently applied to other contexts.

Policy and oversight arrangements are designed to impact on outcomes. This means that when no associations are reported for variables there is often something mitigating the variable's risk. Where a variable is not associated with crashes in New Zealand it may therefore be associated with crashes elsewhere. Speed differential and officer characteristics are examples of variables that may be moderated by New Zealand policy.

Conclusion

This study set out to describe general descriptive statistics, identify patterns and concentrations of risk, and identify if a power few of pursuits and crashes exists amongst officers. Answers to these questions were identified. However, the author is necessarily circumspect due to problems with data and the complexity of pursuit policy and practice.

The existing literature has grown since the late 1980s in several jurisdictions. Previous research has identified variables that are associated with both positive and negative outcomes. However, these studies are not likely to provide complete lists of relevant variables because they were also limited by data availability. In the United States and Australia, where most research has taken place, there is no sole national police service. Policies and data recording practices therefore vary across these countries and across studies. A key strength of the present study is that it uses nationwide data.

Where variables were identified as useful in previous studies these were explored in this thesis if the data was in the database or able to be added to it. At least 10 potentially important variables could not be obtained. Some, such as weather and traffic were potentially important gaps in this study. These variables should be added to the New Zealand database. Police vehicle type and PPDP driver status, were analysed as they were considered likely to be useful due to their inclusion in policy. These variables, like most other officer demographic and vehicle variables were not associated with crashes.

Analytical techniques were somewhat limited by data availability but were guided as far as possible by previous studies to assist with comparisons. Chi-square was chosen for most analysis. This approach was effective in highlighting some key areas where harm concentrates in a way that can be relatively easily understood by practitioners.

Children and young people, and stolen vehicles, both individually and when combined were identified as potential crash prevention targets due to their association with higher crash likelihoods. Further research is needed to better understand pursuit benefits, although an examination of judicial outcomes for children and young people in general in New Zealand data (Ministry of Justice, 2010) suggests that the evidence of positive outcomes is likely to be weak relative to the evidence of pursuit harm presented in the present study. Consideration should be given to whether children, young people and stolen vehicle pursuits should be restricted or discouraged. At the very least officers and Pursuit Controllers should be much more risk-averse when pursuits involve children and young people or stolen vehicles.

Air support was not associated with reduced crash likelihood and this was unexpected. How air support's tactical role in pursuits might be altered is well outside the scope of this study. However, if the College of Policing (2015) and Alpert (1998) are correct about helicopters reducing pursuit risk then this is not evident in an association between crashes and air support in the New Zealand data. Perhaps too much attention is placed on offender apprehensions and useful gains might be made by focusing on the potential for air support's role to contribute more to crash prevention. This needs further investigation as there are other possible explanations for this finding, but it looks to be an area where useful pursuit crash prevention gains might be made.

Two sets of findings of no significant association with outcomes were unexpected but were nevertheless encouraging. These findings relate to police officer and vehicle variables and crashes, and pursuit count per lead police driver and crashes. While this study is not designed to draw causal inferences, the lack of significant association between these variables is an encouraging indicator that administrative oversight might be sound. Further research across all variables is needed to more confidently form any conclusions about cause and effect. However, it certainly seems plausible that policy and oversight have led to this crash risk consistency as is suggested by scholars previously (Alpert et al., 2000).

Low crash likelihoods for pursuits involving motorcycles might also indicate sound oversight and risk assessments. The crash risk is substantially lower and abandonment rate higher than for other vehicle types. This indicates that a more risk-averse approach might be taken as has been suggested previously (New Zealand Police, 2003). Motorcycles might also more easily escape police.

Further research is needed on this important area of policing if New Zealand Police is going to substantially prevent pursuit crashes through an evidence-based approach to pursuits. This thesis indicates where some useful policy reforms may start and some options for extending the New Zealand pursuits evidence base through further research. As Alpert and Lum (2014) state, police agencies worldwide continue to make decisions based on a range of approaches including conventional wisdom, peer approval, and experience, as well as evidence. It is hoped that the growth of evidence-based policing in New Zealand and elsewhere gains acceptance and its influence over police decision-making and policy eventually leads to a truly evidence-based approach to pursuits and policing more generally. As this thesis has shown, evidence can highlight important harm prevention opportunities, and these opportunities are often not consistent with current police opinions or, more importantly, with current police policy and practice.

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Appendices

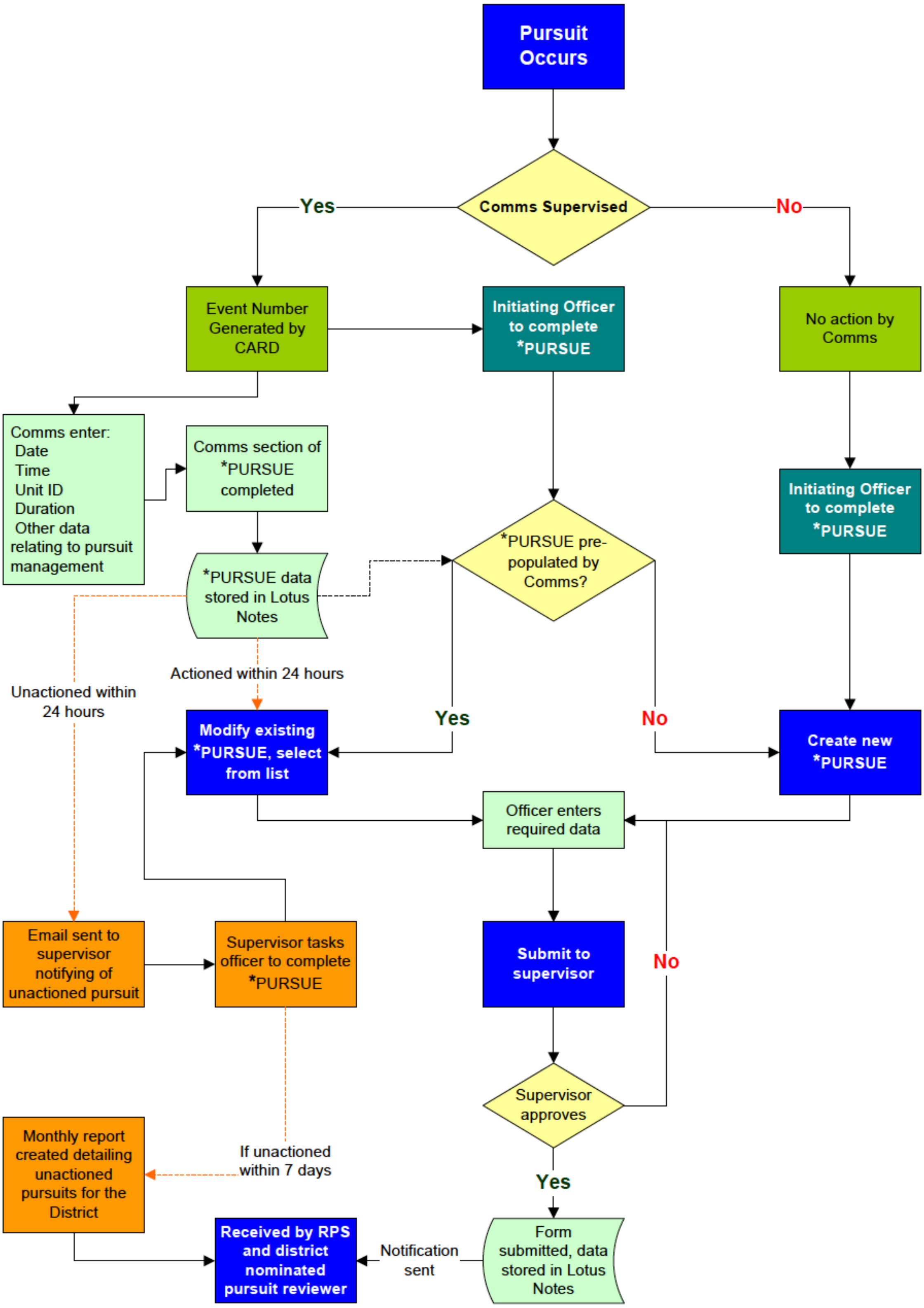
Appendix 1: List of New Zealand Police Pursuit Database Variables

Action Taken	InjuriesTDD3rdPartySerious	PursuitInjuries
Air Support Involved	InjuriesTDDOffendingFatal	PursuitLength
Air Support Requested	InjuriesTDDOffendingMinor	PursuitStartArea
Alias Names	InjuriesTDDOffendingSerious	PursuitStartDistrict
Author	InjuriesTDDPoliceFatal	PursuitStartTime
Card Event Number	InjuriesTDDPoliceMinor	Reason Stopped
Communication Centres	InjuriesTDDPoliceSerious	ReasonStoppedOther
Communication Comments	InjuriesTDDTotalFatal	Ref. No.
Crash During Pursuit	InjuriesTDDTotalMinor	ReviewerComments
Crash Post Abandonment	InjuriesTDDTotalSerious	SearchPhaseCommenced
Date Of Pursuit	InjuryPost	SearchPhaseVehicleLocated
Death During Pursuit	InjuryPursuit	SpeedPoliceMax
Death Post Abandonment	KeyQuestionsAcknowledged	SpeedPosted
Debrief Conducted	KeyQuestionsAsked	Status
Debrief Required	MiddleNames	SubjectFirstName
Dispatcher 1	Nature of Offending Vehicle Crash	SubmittedBy
Dispatcher 2	Nature of Police Vehicle Crash	SupervisorComments
Driver (1) PPDP Clas.	NIAPersonID	TDD Deployment Method
Driver (1) Vehicle Clas.	Occupation	TDD3rdPartyVehicle
Driver (2) PPDP Clas.	OffAlcoholSuspicion	TDDDeployOfficer
Driver (2) Vehicle Clas.	OffDrugSuspicion	TDDInjuries
Driver (Lead)	Offender DOB	TDDLocation
Driver (Secondary)	Offender Ethnicity	TDDMultiple
Evidential Alcohol Test	Offender Identified	TDDPolVehicle
Initiating Vehicle Crew	Offender Licence Status	TDDStopped
Initiating Vehicle Supervisor	OffKnown	TDDSuccessful
Injuries Pursuit 3rd Party Fatal	OffVehicleCrash	TDDUsed
Injuries Pursuit 3rd Party Minor	Off. Family Name	TDDVehicleAvoid
Injuries Pursuit 3rd Party Serious	Off. Gender	Vehicle Reg.
Injuries Pursuit Offending Fatal	Police Vehicle Crashed	Vehicle Type
Injuries Pursuit Offending Minor	PoliceVehicleCrashNatureOther	VehicleBlockStopped
Injuries Pursuit Offending Serious	Pursuit Abandoned Reason	VehicleBlock
Injuries Pursuit Police Fatal	Pursuit Comments	VehicleRecordedStolen
Injuries Pursuit Police Minor	Pursuit Controller	WarningAcknowledged
Injuries Pursuit Police Serious	Pursuit Start Area	WarningGiven
Injuries Pursuit Total Fatal	PursuitAbandonedPerson	WeaponsUsed
Injuries Pursuit Total Minor	PursuitAbandoned	Month
Injuries Pursuit Total Serious	PursuitComments	Offender identified
Injuries TDD 3rd Party Fatal	PursuitControllerName	Age
InjuriesTDD3rdPartyMinor	PursuitDuration	Original licence status
Dual Crash	PursuitEndTime	

Appendix 2: List of Definitions

1C	New Zealand Police code for a suspicious incident.
Air Support	Police helicopter unit based in Auckland City – Referred to as 'Eagle' in New Zealand.
BOLO	North American term for 'Be On The Lookout': a broadcast on the police radio to look for a vehicle for a specified reason.
CBT	Compulsory breath test – usually conducted at a checkpoint, where all drivers are breath tested.
Child	A person aged 13 years and under. This definition comes from the Children, Young Persons and Their Families Act 1989.
Communications Centre	Call centre and radio control rooms based in Auckland (North Comms), Wellington (Central Comms) and Christchurch (South Comms).
EBA	Evidential breath (or blood) alcohol test.
Family Group Conference	A restorative justice process involving the offender's family and the victim, usually instead of court processes. This is a key aspect of Youth Justice in New Zealand and is a requirement under the Children, Young Persons and Their Families Act 1989 to address most youth offending.
Fleeing Driver Incident	New Zealand Police term for police pursuit.
Lead Police Driver	Officer driving police car that initiates pursuit.
Police Districts	Twelve administrative police divisions across New Zealand.
Police Vehicle Type	Police vehicle categorisations for different vehicle types. For example, marked car, motorcycle, prison van.
PPDP (Professional Police Driver Programme)	A training and licensing system whereby officers are graded as Gold, Silver or Bronze driver status following an assessment. Gold drivers can pursue, Silver drivers can pursue with restrictions and Bronze drivers cannot pursue. Most frontline officers hold a Gold status.
Pursuit	'A pursuit occurs when the driver of a vehicle has been signalled by Police to stop, fails to do so, attempts to evade apprehension, and Police take action to apprehend the offender' (IPCA, 2009).
Pursuit Controller	Police Communications Centre Inspector who is Incident Controller for pursuits.
TDD	Tyre Deflation Device – New Zealand Police use the *Stinger* brand of TDD.
Speed Differential	The difference between the reported top pursuit speed and the speed limit at the time.
SPSS	Statistical Package for Social Sciences – Software to conduct statistical analysis.
Young Person	A person aged 14 to 16 inclusive. This definition comes from the Children, Young Persons and Their Families Act 1989.

Appendix 3: Pursuit Notification Data Entry Process



Appendix 4: Map of New Zealand Police Districts