Better to teach than to deter if you cannot do both:
Investigating the effects of education and fines on future traffic offences and collisions

By

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Abstract

No evaluations have been conducted to determine whether Option 4, an Albertan driver education workshop, is effective in reducing future traffic violations and collisions when compared to fines. This thesis followed cohorts of Albertan traffic offenders (N = 1,707), one group who received a traffic fine (n = 1,297) and another which completed an Option 4 workshop (n = 410), one or so year(s) after they committed a traffic violation during two (Campaign one = May 14th and 22nd, 2017, Campaign Two = October 8th and October 14th, 2017) law enforcement campaigns. The goals of this thesis were to: (a) identify offender characteristics associated with Option 4 participation (Study 1), and (b) model time until the occurrence of a violation (Study 2) or a collision (Study 3) one and a half years after either receiving a fine or completing Option 4. For studies 2 and 3, we also established a control group of offenders who did not choose either intervention and only received a fine.

Information was extracted from the PROS, JOIN, ROADS, and Enforcement Services Records Management databases and was merged with the 2016 Canadian census to determine median household income.

Study 1 included the percentage of offenders who chose to participate in Option 4 versus those who received a fine and fitted logistic regression models with the choice of receiving a fine or participating in Option 4 as the outcome variable. Studies 2 and 3 included the percentages of offenders who had a follow up violation and collision and used survival analysis to model time to subsequent violations and collisions between the fine and Option 4 groups. Proportional hazard models evaluated the impacts of taking option 4 versus receiving a fine.

Results from study one showed that 37% of offenders chose to participate in Option 4 while the remainder (63%) chose to receive a fine. After controlling for our predictors (age,

geography, median area income, sex, campaign/season, prior collisions, prior violations), offenders were more likely to participate in Option 4 if they participated in the second campaign (adjusted odds ratio (AOR) = 2.16, 95% confidence interval (CI): 1.63, 2.85), committed a distracted driving (AOR = 2.52, 95% CI: 1.32, 4.82), and/or failure to stop at a stop sign violation (AOR = 11.85, 95% CI: 4.73, 29.73) two years before being stopped during one of the campaigns. Offenders in their twenties (AOR = 0.47, 95% CI: 0.32, 0.69) and offenders who committed a violation classified as "other" (AOR = 0.49, 95% CI: 0.28, 0.87) were less likely to participate in Option 4.

In the survival analysis, we found evidence that, compared to all offenders who received a fine, participating in Option 4 reduced the hazard of committing a violation one and a half years later (adjusted hazard ratio (AHR) = 0.56, 95% CI: 0.44, 0.72). We also found evidence that female offenders (AHR = 1.24, 95% CI: 1.05, 1.47), as well as offenders who committed one (AHR = 1.61, 95% CI: 1.31, 1.98), two or more (AHR = 3.35, 95% CI: 2.74, 4.09) violations prior to being stopped during one of the campaigns had the highest risk for future violations.

Study 3 found no evidence that completing Option 4 reduced the risk of being involved in a collision one and a half years later. Offenders who committed 2 or more violations two years before being stopped (AHR = 1.98, 95% CI: 1.16, 3.38) were more likely to be involved in a future collision, while offenders who were 19 years or younger (AHR = 5.39, 95% CI: 2.24, 12.97), in their thirties (AHR = 2.28, 95% CI: 1.01, 5.13) and forties (AHR = 3.10, 95% CI: 1.41, 6.78) were also more likely to be involved in a collision when compared to offenders 50 years or older. Offenders who received fines, without a choice to participate in Option 4, had a reduced risk (AHR = 0.57, 95% CI: 0.34, 0.96) of being involved in a collision one year later as compared with offenders who willingly chose a fine.

Option 4 is effective in reducing the risk of future violations. As such, this thesis recommends continuing and expanding Option 4 programming throughout Alberta alongside issuing fines.

Preface

This thesis is an original work by Jakob L. Koziel. This thesis received ethics approval from the University of Alberta under the title “The effects of education and fines on future traffic offences and collisions”, study ID: Pro00088817. An amendment was created and approved on May 23, 2019, study ID: Pro00088817_AME2. Preliminary results of the thesis were presented at the 11th Annual International Conference on Urban Traffic Safety on August 22, 2019.

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Chapter 1 Background

1.1 Introduction

Traffic collisions have affected much of the developed and developing world and have the potential of becoming a leading cause (5th) of death by the year 2030 (World Health Organization, 2010). In 2016, more people were killed due to motor vehicle injuries than due to tuberculosis and HIV, among others (World Health Organization, 2018). Road traffic injuries and fatalities disproportionately occur in younger populations and can contribute to significant future rehabilitative costs and care (Redelmeier et al., 2003). Given the significant impact on victims and society, researchers and policy makers have highlighted the importance of preventing collisions as well as understanding the etiology of collisions and developing evidence-based interventions that reduce their incidence (Redelmeier et al., 2003; World Health Organization, 2010, 2018; Zhang et al., 2013).

Various evidence-based interventions include engineering safer vehicles, roads, and other external modalities as ways in preventing future collisions (World Health Organization, 2018). Yet, throughout the decades, the literature has consistently shown that unlike other determinants of mortality and morbidity such as complex infectious or degenerative diseases, traffic collisions are unique in their etiology as they are often caused suddenly and unexpectedly due to certain dangerous driving behaviours such as traffic violations (Redelmeier et al., 2003). As a result, numerous road safety enforcement and educational interventions oriented towards changing driving behaviour have been implemented in the last century with differing degrees of success (Struckman-Johnson et al., 1989; Wåhlberg, 2010, 2011, 2013). Each intervention seeks to prevent drivers from engaging in risky behaviours by encouraging safer driving habits (Wåhlberg, 2010). Yet, how each strategy manages to change driving behavior varies. One

strategy seeks to change behavior by deterring offenders from engaging in future unlawful behavior while another seeks to educate offenders in the hopes that they will internalize attitudes conducive towards safer driving behaviour, thus leading to a subsequent reduction in collision risk (Struckman-Johnson et al., 1989; Wåhlberg, 2010, 2011, 2013).

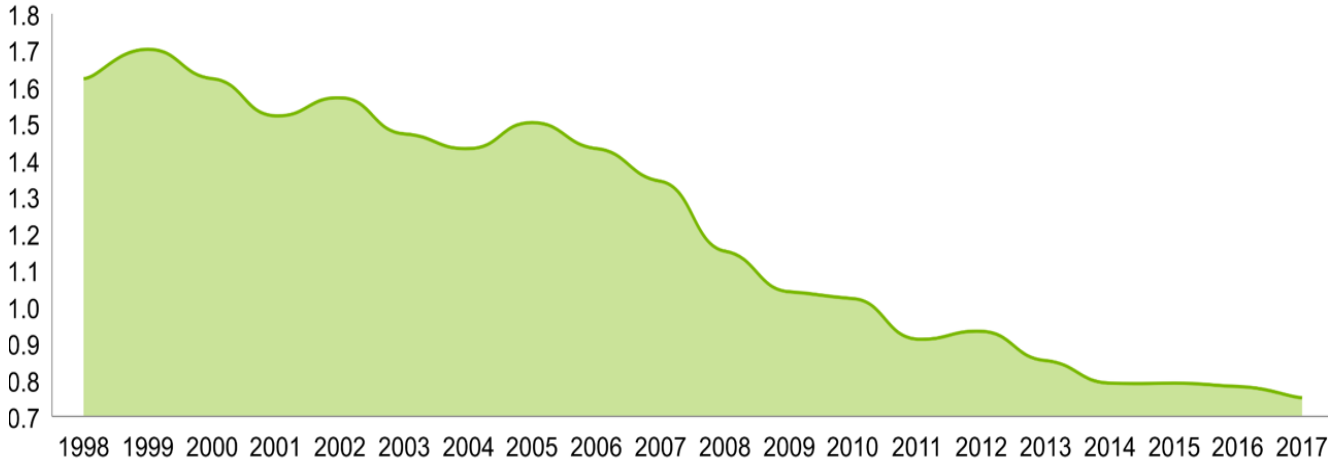
While traffic accidents and violations on the surface can be seen as two separate forms of inquiry, violations are closely linked with collisions (Zhang et al., 2013). Given such a direct relationship, researchers have suggested that identifying and controlling for risk factors associated with traffic violations as well as implementing strategies focused on reducing rates of violations will simultaneously reduce rates of collisions (Zhang et al., 2013). During various targeted law enforcement campaigns within Sherwood Park in 2017, traffic offenders who were caught violating a traffic rule were are given the option of attending an *Option 4* educational workshop in lieu of having to pay for their fine with the goal of the workshop seeking to change offender behaviour (Narbonne, 2017). Option 4 is the fourth option that traffic offenders can select as an alternative to paying a fine (Option 1), pleading not guilty through mail (Option 2) or in court (Option 3) (Alberta Occupant Restraint Program, 2019). However, there has been no evaluation of Option 4 and whether it is effective in reducing the risk of future violations and collisions. Additionally, there are no studies that have been conducted that have assessed the risk of future traffic violations and collisions for traffic offenders who attend these educational programs when compared with those who only paid a fine in a Canadian context.

1.2 Background

1.2.1 Epidemiology of traffic collisions in Canada and Strathcona County

Canadian data indicate that the frequency and rates of fatalities and injuries associated with motor vehicle collisions have been steadily decreasing in the last 20 years. Since 1998, the

fatality rate has decreased from a high of 1.7 (per 10,000) in 1999 to a low of 0.75 (per 10,000) in 2017 (Figure 1.1) (Statistics Canada, 2019).



Source: Statistics Canada. Canadian Motor Vehicle Traffic Collision Statistics: 2017
https://www.tc.gc.ca/eng/motorvehiclesafety/canadian-motor-vehicle-traffic-collision-statistics-2017.html

Figure 1.1: Fatality Rate (Per 10,000 motor vehicle registered drivers)

Since data have been collected on the subject matter, the frequency and rate of injuries and fatalities due to collisions today, at the national level, are the lowest they have ever been (Statistics Canada, 2019). In Strathcona County, an Albertan community containing one major urban centre (Sherwood Park) and multiple rural farm areas, total collision rates have declined from 2007 to 2016 (2366 and 2178, respectively) (Hameed & Rawson, 2017).

Despite a national downward trend in motor vehicle collisions, motor vehicle crash fatalities continue to disproportionately affect Albertans relative to other provinces. When compared with national estimates (5.0 per 100,000), Alberta has a higher rate of motor vehicle fatalities (7.1 per 100,000) with motor vehicle injuries being a leading cause (3rd) of deaths related to injury in Alberta (Injury Prevention Center, 2018; Statistics Canada, 2019). Despite decreases in total collisions, Strathcona county roads had a 55% increase in major injury collision rates between 2007 and 2016 (Hameed & Rawson, 2017). In the last decade or so (2010-2019), sixty individuals in Strathcona County were killed while 449 sustained major

injuries due to motor vehicle related incidents (Strathcona County, 2020). Over 21,500 crashes had occurred in Strathcona County during this time frame costing the jurisdiction an indirect cost of over 400 million dollars (Strathcona County, 2020). Given these grim statistics, evaluating whether educational or enforcement strategies, as well as which groups would benefit the most from said strategies, are essential in making Albertan roads safer.

1.2.2 Environmental and vehicular risk factors

Various environmental and vehicular factors have been identified by the literature as important predictors of collisions and violations. In order to effectively maneuver within road networks drivers will observe the conditions of the road environment as well as other drivers and adapt their driving behaviors accordingly (Wierwille, 1993, as cited in Kim et al., 2016, p. 330). Thus, factors related to weather conditions such as adverse weather events and precipitation, as well as road design features such as lack of street lighting, wider streets and traffic lanes have all been associated with collisions and violations (Ewing & Dumbaugh, 2009; Liu et al., 2016; Qiu & Nixon, 2008; Saha et al., 2016; Theofilatos & Yannis, 2014; Zhang et al., 2013). Additionally, driving during weekends, at nighttime, and at high traffic volume hours as well as in rural areas have been associated with higher rates of traffic accidents (Abdel-Aty & Radwan, 2000; Kmet et al., 2003; Massie et al., 1995; Valent et al., 2002; Zhang et al., 2013). Lastly, commercial vehicles and vehicles deemed unsafe have also been predictors of collisions (Zhang et al., 2013). It may be hypothesized that environmental factors such as unfavourable weather events impact road surfaces and visibility making driving more risky while driving during the above mentioned hours and days increase the risk of collisions due to a greater density of drivers on the road, particularly within small spaces, as well as higher proportion of populations engaging in risky

activity such as drinking and driving (Ewing & Dumbaugh, 2009; Massie et al., 1995; Saha et al., 2016; Valent et al., 2002; Zhang et al., 2013).

1.2.3 Human risk factors

Research has consistently shown associations between age, socioeconomic status, residence, driving history, intoxication, and sex and the occurrence of collisions and violations (Factor et al., 2008; Li et al., 2011; Zhang et al., 2013). Research has found age to be a significant factor in crash risk with some finding groups such as young (16-29) drivers with being most at risk for crashes while others finding drivers in their twenties and thirties as groups most at risk for collisions (Li et al., 2011; Regev et al., 2018). Additionally, age has also been identified as a risk factor for multiple violations including failure to stop at stop signs and speeding, with younger drivers, particularly younger male drivers, as groups most at risk (Li et al., 2011; Retting et al., 2003). Socioeconomic status has also been found to be inversely correlated with collisions and violations (Factor et al., 2008). Residence has also been associated with motor vehicle collisions with rural drivers having a higher likelihood of being involved in collisions than urban drivers while it is inconclusive regarding traffic violations with some research showing rural drivers being more at risk while others finding the opposite (Blatt & Furman, 1998; Keay et al., 2009; Zhang et al., 2013). Rural areas also contain higher speed limits, less safety road signage, and populations who are at a higher risk for being involved in collisions than urban areas with rural drivers having psychological and attitudinal differences in driving risk perceptions (Kim et al., 2012; Rakauskas et al., 2009).

Drivers who are extroverted, as well as drivers who exhibit lower levels of agreeableness, conscientiousness, and feelings of internal locus of control, are more likely to get into car accidents compared to drivers who do not exhibit such personality traits (Arthur et al., 1991;

Clarke & Robertson, 2005). However, a recent meta-analysis found that these studies tended to be of poor quality and after controlling for probable moderators found personality to be a weak predictor of future accidents particularly in comparison to other far stronger human predictors of collisions such as driving history (Wåhlberg et al., 2017). Driving history, in particular past instances of reckless or dangerous driving (i.e. violations), as well as engagement in current behaviours such as drinking and driving, have been found to be a predictor of collisions (Alver et al. 2014; Li et al., 2011; Siskind et al., 2011; Villaveces et al., 2011; Zhang et al., 2013). Lastly, research has concurred that male drivers are the group who commit the largest proportion of collisions and violations (Zhang et al., 2013). The importance of highlighting the aforementioned risk factors are essential for understanding which groups to target for effective programming and also effective at determining which groups may benefit from said programming and which groups may be deterred from committing violations (Zhang et al., 2013).

1.2.4 Deterrence Theory

The theoretical underpinnings of deterrence lie at the heart of many interventions focused on reducing traffic violations and making drivers compliant with traffic rules to reduce future risk of traffic collisions (Davey & Freeman, 2011). Deterrence can simply be understood as the "omission of an act as a response to the perceived risk and fear for contrary behaviour" (Gibbs, 1975, p. 2). In other words, effective crime and collision prevention are achieved by having traffic offenders become fearful of future punishment or other harmful consequences (i.e. being injured or dying in a collision) as a result of their dangerous driving and modify their behaviors accordingly (Davey & Freeman, 2011; Linden, 2009). The stipulation that effective prevention of future deleterious outcomes from occurring by making individuals fear future punishment, as well as serve as an example for others, has been discussed since antiquity (Plato, 2008).

However, modern work into what is known today as deterrence theory officially began in the 17th Century and continued to be modified throughout the 20th Century (see Beccaria, 1963; Becker, 1968; Bentham, 1907; Gibbs, 1975). According to deterrence theorists, human beings are rational creatures that understand the consequences of their actions and will assess each situation by weighing the costs and benefits of their choices (Paternoster, 2010). From this perspective, individuals will choose to commit a crime if the criminal behaviour has a greater benefit than cost associated with it (Paternoster, 2010). In order to maximize fear of punishment, legal punishments that are administered soon after the offense has been committed, are greater in scale, and more likely to be implemented will become more costly than beneficial for the individual and thus deter individuals from committing crimes (Paternoster, 2010).

How individuals become deterred from committing crimes can be understood via two mechanisms; general and specific deterrence (Davey & Freeman, 2011; Stafford & Warr, 1993; Walter & Studdert, 2015). General deterrence refers to individuals being deterred from committing criminal behaviour if they either observe others being punished for committing a crime or are reminded of the potential consequences that will arise if they commit an offence (Davey & Freeman, 2011; Stafford & Warr, 1993; Walter & Studdert, 2015). In contrast, specific deterrence refers to personal experience with law enforcement, for example, being penalized when one is caught committing a traffic offence (Davey & Freeman, 2011; Stafford & Warr, 1993; Walter & Studdert, 2015). Both deterrence mechanisms are believed to reduce the likelihood of criminal actions in the future (Davey & Freeman, 2011; Stafford & Warr, 1993; Walter & Studdert, 2015). Drawing from centuries of observations and research, deterrence theory forms the bedrock of most criminal justice systems operating today and serves as a

foundation for most traffic enforcement strategies (i.e. fines) focused on reducing violations and collisions (Davey & Freeman, 2011).

1.2.5 Law Enforcement Interventions

Law enforcement personnel are responsible for maintaining traffic safety within their respective jurisdictions by enforcing laws and regulations that govern acceptable road use behaviour (Stanojević et al., 2013; Zaal, 1994). Traffic enforcement can be conceptualized as activities conducted by police services that are aimed at improving the efficiency of road networks by controlling driver behaviour using preventive and punitive strategies (Zaal, 1994). Reviews and studies have concluded that law enforcement measures and programs, such as forcibly removing licenses and legislation, are effective in reducing traffic violations and accidents (Blais & Dupont, 2005; Masten & Peck, 2004; Redelmeier et al., 2003; Stanojević et al., 2013; Staton, et al., 2016).

Some of the most effective preventive strategies in reducing traffic accidents and offenses include campaigns that incorporate mass media to increase awareness of punishments surrounding various traffic violations (i.e. *Click it or Ticket*), as well as Selective Enforcement Programs (STEP) which combine the use of mass media and targeted law enforcement for particular behaviours in an effort to deter drivers from committing these offences (Dussault, 1990; Engel, 1980; Jonah et al., 1982; Jonah & Grant, 1985; Morgan, 2015; Thomas et al., 2011; Vasudevan et al., 2009). The philosophy underpinning STEP programs is that increasing law enforcement activity in locations with a history of high traffic violations and accidents will deter drivers from engaging in risky driving behaviours given the high likelihood of being apprehended (Zaal, 1994). Over time, the distribution of enforcement personnel in areas with high problematic activity will heighten a driver's intuition that police may be in the area even if

they may not be (Zaal, 1994). This heightened certainty will then further deter drivers from committing traffic violations, with or without the presence of law enforcement, thus decreasing the chance of accidents from occurring, and reducing the overall frequency of violations and accidents within jurisdictions (Zaal, 1994). Similarly, the rationale behind such interventions is in heightening the driver's fear of being punished, which will inadvertently deter them from committing violations and simultaneously reduce the risk of collisions (Zaal, 1994).

1.2.6 Fines

Imposing traffic tickets is one of the most common punitive tools that law enforcement personnel utilize to deter drivers from committing future traffic violations (Luca, 2015). Despite their widespread use, the effectiveness of traffic tickets in reducing future violations and accidents has not been conclusively demonstrated (Luca, 2015). Some studies have found little or no evidence that fines reduce the risk of subsequent violations or collisions while others have found them effective (Lawpoolsri et al., 2007; Li et al, 2011; Luca, 2015; Martin et al., 1993; Redelmeier et al., 2003; Wagenaar et al., 2007). While fines can be seen as a panacea, the use of fines has been criticized. Among drivers who routinely commit traffic violations, fines can have little to no deterrent qualities as they may not be perceived as a severe enough punishment and thus not lead to any modification in driving behaviour (Li et al, 2011; Zaal, 1994). As such, educational programs that teach or reteach safe driving behaviours so that individuals will learn to drive safely and not commit violations during times when there are no police officers present can be seen as another option to fines (Struckman-Johnson et al., 1989; Wåhlberg, 2011).

1.2.7 Theory of planned behavior

The implicit processes of how an individual learns and changes their driving behaviour has been explored in the literature utilizing various theoretical models, including the theory of

planned behavior (TPB) (Tavafian et al., 2011). The focus of TPB is on an individual's intentions on performing one or more behaviors with greater intentions leading to a higher likelihood of performing said behaviour (Ajzen, 1991). The theory stipulates that the more positive subjective norms related to the behavior, which is influenced by social pressures, that an individual has towards that behavior, along with a positive attitude in performing that behavior, the greater the individual's intention will be towards performing that behavior (Ajzen, 1991). Additionally, the more likely one perceives that they have control over their behaviour, the greater their intention will be of performing that behaviour (Ajzen, 1991). TPB has successfully been used to assess and predict many driving behaviours as well as guide in the development of various classroom or e-learning module educational interventions known as driver improvement programs (Tavafian et al., 2011; Markl, 2016).

1.2.8 Educational Programs (Driver improvement programs)

Driver improvement programs (DIP) attempt to elicit positive behaviour changes in drivers' habits by modifying behaviours, knowledge, and attitudes related to traffic safety (Struckman-Johnson et al., 1989). DIP activities can include counselling, warning letters, as well as post-licensing educational workshops and other measures that raise awareness surrounding traffic safety and improve attitudes towards safer driving behaviours (Masten & Peck, 2004; Struckman-Johnson et al., 1989; Wåhlberg, 2010, 2011, 2013). Like fines, DIPs are designed to promote safer driving practices and greater compliance with traffic laws (Wåhlberg, 2010). Yet, unlike fines and other law enforcement measures, DIPs assume that violations and collisions are due to a lack of knowledge surrounding traffic safety rather than drivers simply weighing the costs and benefits of breaking traffic laws (Struckman-Johnson et al., 1989; Wåhlberg, 2013). Given that a lack of knowledge directly contributes to the occurrence of violations and collisions,

educational workshops tend to construct their curriculums around teaching traffic safety and modifying driver attitudes (Struckman-Johnson et al., 1989; Wåhlberg, 2013).

Despite decades of work focused on DIPs, research on the effectiveness of DIPs is inconclusive, with many studies indicating that exposure to DIPs is not associated with a reduction in future collision incidents. An overview of over 15 reviews and studies over the decades by Wåhlberg (2018) concluded that DIPs do not have any effect on reducing motor vehicle accidents or that the effects are small as to have no meaningful significance. A Cochrane review also echoed this sentiment (Ker et al., 2003). Despite its lackluster effect on reducing the risk of crashes, the literature has found evidence that DIPs have an impact on reducing future violations. Two reviews on the subject matter each found that DIPs are associated with a reduction in traffic violations (Masten & Peck, 2004; Struckman-Johnson et al., 1989).

1.3 Why is more research needed?

Establishing effective evidence-based traffic safety plans are essential in reducing the incidence and prevalence of collisions and violations in Alberta. Two such initiatives have been the Alberta Traffic Safety Plan (TSP), initiated in 2007, and Strathcona County's Traffic Safety Strategic Plan (TSSP) (Government of Alberta, 2015; Rawson & Narbonne, 2018). The purpose of both plans is to reduce deaths and injuries related to motor vehicles by establishing safer roads, educating Albertans on traffic safety, and enforcing traffic laws (Government of Alberta , 2015; Rawson & Narbonne, 2018). The TSP and TSSP will achieve these outcomes by implementing numerous actions including, but not limited to, increasing law enforcement campaigns to reduce speeding behaviours, as well as educating Albertan drivers on safe driving (Government of Alberta, 2015; Rawson & Narbonne, 2018). Since the TSP has been implemented, there has been an 18% decrease in serious injuries and a 32% decrease in motor

vehicle collision deaths in Alberta along with decreases in the rate and frequency of collisions since 2007 (Government of Alberta, 2015). However, it is unknown whether these decreases in injuries and fatalities were intricately linked to the TSP. Underpinning the TSSP is the Vision Zero philosophy (Rawson & Narbonne, 2018). Vision Zero is a road safety strategy with the stated objective of eliminating all injuries and fatalities related to traffic collisions while subsequently increasing safer means of conveyance (Conner, 2017). Despite the success that the rest of the province has had in achieving the objectives outlined in the TSP, collisions resulting in injuries within Strathcona County rose 10.2% between 2006 and 2016 (Rawson & Narbonne, 2018).

To address these negative trends, Strathcona County's Royal Canadian Mounted Police (RCMP) and Enforcement Services have incorporated public education programming, such as Option 4, as part of the TSSP to reduce the incidence of traffic offences and collisions in Strathcona County (Rawson & Narbonne, 2018). Option 4 is a DIP designed for drivers who have committed a traffic offence (Alberta Occupant Restraint Program, 2019). The program has been implemented in Alberta since 1988 (Narbonne, 2017). Initially, Option 4 was designed to teach drivers on how to handle and maintain care of child restraints, such as booster seats, child safety seats, etc., as opposed to drivers simply paying a traffic fine (Alberta Occupant Restraint Program, 2019). The name "Option 4" originates from the three options that are displayed on the back of a violation notice that drivers receive when they are caught committing a traffic violation in Alberta which are paying a fine (Option 1), pleading not guilty through mail (Option 2) or in court (Option 3) (Alberta Occupant Restraint Program, 2019). Participation in the workshop is strictly voluntary (Rawson & Narbonne, 2018). The Option 4 framework has also expanded to incorporate drivers who were caught committing traffic violations other than misuse of child

restraints such as speeding, failing to stop at a stop sign, among many others (Rawson & Narbonne, 2018). Similar to child restraints, the Option 4 program is used to educate drivers and other vehicle occupants on traffic safety (Rawson & Narbonne, 2018). Each session not only educates attendees on the Vision Zero philosophy but also asks attendees on how law enforcement personnel can improve traffic safety measures as a means of helping officers identify gaps in driver education (Rawson, 2018). Despite the potential societal benefits, such diversion programs may have in reducing future traffic offences and collisions, no evaluations have been conducted on the effectiveness of *Option 4* programming and whether the program reduces the risk of future violations and/or collisions.

Establishing the effectiveness of Option 4 may inform Strathconca's Safety Strategic Plan 2020 while results from the thesis may provide evidence for expanding such programming across the province. Results from the thesis may also have global implications in our understanding regarding educational and law enforcement strategies given the perception that they are oppositional in nature (Potter & Akers, 2013). That is, one strategy (Deterrence) seeks to impose fear and deter drivers from engaging in dangerous behaviors while another (Educational) seeks to educate drivers in the hopes that drivers will learn positive attitudes and behaviours in relation to traffic safety (Potter & Akers, 2013). Investigating this dichotomy and understanding which strategy (i.e. driver improvement programs or fines) leads to safer driving outcomes, will assist law enforcement personnel in Strathcona County in ensuring that "no one is seriously injured or killed while traveling on Strathcona County's road network" (Rawson & Narbonne, 2018, p. 3).

1.4 Context for Research (Law Enforcement Campaigns)

1.4.1 First Campaign

The first campaign, *Neighbourhood Traffic Safety*, was conducted between May 14th and 22nd, 2017 (Rawson, 2017). The Neighbourhood Traffic Safety campaign focused on addressing residential speeding in and around Sherwood Park (Rawson, 2017). The goal of the campaign and the focus of the Option 4 workshops during this campaign were to heighten awareness among attendees on the risks speeding poses to pedestrians (Rawson, 2017). During the *Neighbourhood Traffic Safety* campaign, offenders who were caught committing any traffic violation were offered the choice of either paying their fine or attending the option 4 program (Rawson, 2017). All offenders who were stopped from May 1st to May 13th, 2017 received a fine and were not provided the opportunity to participate in the Option 4 workshop and served as a comparison group in this research (Rawson, 2017).

1.4.2 Second Campaign

A second campaign, *Stop Sign Safety Campaign*, was also held in Sherwood Park in the fall of 2017 (October 8th to October 14th, 2017) (Rawson, 2018). Unlike the first campaign, the second campaign focused on increasing stop sign compliance rather than residential speeding (Rawson, 2018). The campaign and Option 4 workshops focused on heightening awareness regarding stop sign compliance and how offenders should maneuver around stop-controlled intersections (Rawson, 2018). The formats of the workshops were essentially the same with the only difference being the focus of the campaign changing from residential speeding to stop sign compliance (Rawson, 2018). Like the first campaign, offenders who were stopped during the campaign were given the option of either paying their fine or attending the option 4 program

(Rawson, 2018). We also established a control group of offenders (September 25th to October 7th) that were not given the opportunity to participate in the Option 4 workshop.

1.5 Objectives and Hypotheses

This thesis identified factors that are associated with engagement in a driver improvement program (Option 4) and examined whether participating in Option 4 programming decreased the risk of future traffic violations and collisions. The objective for paper one (Chapter 2) is to identify characteristics associated with participating in an Option 4 workshop. In paper one, we hypothesize that offenders who identify as female and offenders who are under the age of 20 will choose to participate in Option 4 as opposed to receive a fine. The objective for paper two (Chapter 3), will be to model time until the occurrence of a traffic violation to determine whether participating in Option 4 or receiving a fine decreased the risk of future traffic violations. For paper two, we hypothesize that participating in Option 4 will lead to slower time to subsequent violations and decreased the risk in committing future traffic violations compared to those who only received a fine. The objective for paper three (Chapter 4) will be to model time until the occurrence of a traffic collision to determine whether participating in Option 4 or receiving a fine decreased the risk of future traffic collisions. For paper three, we hypothesize that participating in Option 4 will lead to slower time to subsequent collisions and decreased the risk in future traffic collisions compared to those who only received a fine. Chapter 5 will summarize results from the three papers as well as discuss limitations present in each paper and direction for future research to take. Chapter 6 will discuss the public health implications of these papers and present recommendations, based on the results, for law enforcement to take towards making Albertan roads safer.

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Chapter 2: Predictors of driver improvement program attendance

2.1 Introduction

Completion of educational interventions tailored to traffic safety, otherwise known as Driver Improvement Programs (DIP), have been shown to reduce the incidence of traffic violations and improve traffic safety (Masten & Peck, 2004; Struckman-Johnson et al., 1989; Wåhlberg, 2011, 2013). However, injury prevention and traffic safety researchers often overlook or do not investigate who might be interested in participating in a DIP.

Identifying who is more likely to attend health promotion workshops has been thoroughly investigated on public health topics not related to traffic safety, such as general health among seniors, cultural awareness, and parenting (Bowman et al., 2016; Fleming et al., 2015; Williams et al., 1998). However, only two evaluations have assessed the relationship between various predictors and traffic safety workshop attendance in detail (Barrett, 2018; Kloeden & Hutchsinon, 2006).

Using a mixed method approach, Barret (2018) utilized regression analyses as well as participant and stakeholder interviews to evaluate a DIP focused on addressing speeding in England and compared reoffending rates between those who took the course versus those who decided to receive a fine. In his interviews, Barret (2018) found that most drivers who chose to participate in the traffic educational workshop did so due to economic reasons such as avoiding paying fines as well as avoiding additional penalty points which could result in increases to their insurance premiums. Kloeden and Hutchinson (2006) evaluated whether fine or participation in educational workshops reduced future violations and collisions. They found differences in characteristics between those who chose to participate in educational groups versus fine groups.

Female drivers were more likely to choose to participate in educational workshops than male drivers, as were younger drivers (under age 20) compared to older drivers (Kloeden & Hutchinson, 2006). Harano and Peck (1972) utilized an experimental design in which drivers were assigned, as opposed to self-selecting their treatment, into two groups: one that attended group meetings as part of an educational curriculum, and a comparison group that did not undergo the educational programming and instead only had to pay a fine. While the primary goal of the study was to evaluate the effectiveness of the educational programming in reducing future traffic violations and collisions, the traffic offenders assigned to take the workshop were more likely to be younger and have a history of driving violations than those who were assigned to pay their fine (Harano & Peck, 1972). Findings from these studies suggest that a combination of prior driving behaviours, demographic and socio-economic factors can play a role in influencing whether someone will decide to participate in an educational workshop designed for traffic safety (Barrett, 2018; Harano & Peck, 1972; Kloeden & Hutchinson, 2006).

Harano and Peck's study (1972) found that program efficacy, particularly for males, was largely dependent on the individual characteristics of the course participants. Specifically, drivers who did not experience a traffic collision prior to completing the course had the highest reduction in the number of collisions and traffic violations one year after completing the course (Harano & Peck, 1972). Treatment was also effective in reducing the accidents for drivers who were older (Harano & Peck, 1972). Thus, identifying offender groups that are more likely to attend traffic safety workshops, as well as which groups are not, is often the first step in evaluating who may benefit the most from such programming as prior research has found some groups may respond favourably to such programming. Unfortunately, relative to other work conducted on traffic safety, only a few studies have explored the topic of predictors surrounding

traffic safety workshop attendance and no studies have been conducted on Canadian or Albertan samples (Barrett, 2018; Kloeden & Hutchison, 2006). Additionally, no studies have explored associations between specific traffic offences and traffic safety workshop attendance and no studies have investigated who may be interested in participating in an Albertan DIP otherwise known as Option 4.

2.2 Context for the Present Study

Option 4 is a 90-minute DIP that has been implemented in Alberta since 1988 (Narbonne, 2017). The name "Option 4" originates from the three options that are displayed on the back of a violation notice that drivers receive when they are caught committing a traffic violation in Alberta which are paying a fine (Option 1), pleading not guilty by mail (Option 2) or in court (Option 3) (Alberta Occupant Restraint Program, 2019). Over the years, Option 4 workshops have generally been implemented during various Albertan law enforcement traffic campaigns. Initially, Option 4 was designed to teach drivers on how to handle and maintain care of child restraints, such as booster seats, child safety seats, etc., as opposed to drivers simply paying a traffic fine (Alberta Occupant Restraint Program, 2019). The Option 4 framework has since expanded to incorporate drivers who were caught committing traffic violations other than misuse of child restraints such as speeding, failing to stop at a stop sign, among many others (Rawson & Narbonne, 2018). Similar to child restraints, the Option 4 program is used to educate drivers and other vehicle occupants on traffic safety offence (Rawson & Narbonne, 2018). Each session not only educates attendees on the Vision Zero philosophy but also asks attendees on how law enforcement personnel can improve traffic safety measures as a means of helping officers identify gaps in driver education (Rawson, 2018).

In 2017, Strathcona County's Royal Canadian Mounted Police (RCMP) and Enforcement Services launched two law enforcement campaigns. The first campaign, *Neighbourhood Traffic Safety*, was conducted between May 14th and 22nd, 2017 and focused on addressing residential speeding in and around Sherwood Park (Rawson, 2017). The goal of the campaign and the focus of the Option 4 workshops during this campaign were to heighten awareness among attendees on the risks speeding poses to pedestrians (Rawson, 2017). A second campaign, Stop Sign Safety Campaign, was also held in Sherwood Park in the fall of 2017 (October 8th and October 14th, 2017) (Rawson, 2018). Unlike the first campaign, the second campaign focused on increasing stop sign compliance rather than residential speeding (Rawson, 2018). The campaign and Option 4 workshops focused on heightening awareness regarding stop sign compliance and how drivers should maneuver around stop-controlled intersections (Rawson, 2018). The formats of the workshops were essentially the same with the only difference being the focus of the campaign changing from residential speeding to stop sign compliance (Rawson, 2018). During both campaigns, drivers who were caught committing any traffic violation were offered the choice of either paying their fine or attending the option 4 program (Rawson, 2017, 2018).

This study is novel in many respects by addressing multiple knowledge gaps that currently exist in the literature. First, this will be one of the first in the literature to focus specifically on correlates of participation in a traffic safety workshop (i.e. Option 4). This study is also the first to examine whether committing specific driving violations, such as speeding and failing to wear a seat belt, predict traffic safety workshop attendance among a Canadian sample of traffic offenders. Prior research found that females and drivers under the age of 20 were more likely to choose to participate in educational workshops than receive fines as well as factoring in the cost of fines when weighing their decisions to participate or not (Barrett, 2018; Harano &

Peck, 1972; Kloeden & Hutchinson, 2006). Therefore, the primary objective of our study is to attempt to replicate these findings, and to identify other driver and demographic related predictors of Option 4 attendance. Thus, we hypothesized that female traffic offenders and offenders under the age of 20 were more likely to choose to participate in educational workshops than receive fines.

2.3 Methods

2.3.1 Study population and design

The study population used for this analysis were Albertan traffic offenders who were pulled over by Peace Officers as well as the Royal Canadian Mounted Police (RCMP), due to committing any traffic violation, during the *Neighbourhood Traffic Safety* and the *Stop Sign Safety Enforcement* Campaigns in Sherwood Park, Alberta in 2017. The *Neighbourhood Traffic Safety* campaign was conducted between May 14th and 22nd, while the *Stop Sign Safety* campaign was conducted between October 8th to October 14th (Rawson, 2017; 2018). The *Neighbourhood Traffic Safety* campaign focused on addressing residential speeding while the Stop Sign Safety campaign focused on increasing stop sign compliance in and around Sherwood Park (Rawson, 2017; 2018). During each campaign, all traffic offenders who were interested in attending the Option 4 workshop were instructed that upon completion of a workshop, their traffic offence would be reduced to a warning and would not have to pay a fine. These offenders were categorized into a group called “option 4”. Traffic offenders who opted not to participate in an option 4 workshop and instead receive a fine were classified into a group called “fine”. Lastly, non-Albertan offenders, defined as those who both did not have Albertan License plate numbers and Postal Code residences, were excluded from the study.

2.3.2 Data Sources

Data used for this study were contained and linked across several administrative databases, including the Enforcement Services Records Management System, Justice Online Information Network (JOIN), and the Police Reporting and Occurrence System (PROS) databases as well as the 2016 Canadian census. All data were accessed, except for the 2016 Canadian census, from the Enforcement Services located in Sherwood Park, Alberta.

Data describing demographic characteristics of all offenders were collected from the Enforcement Services Records Management System. The Enforcement Services Records Management System is an in-house data warehouse environment that contains electronic records of offenders who were pulled over by the Sherwood Park enforcement services due to committing a traffic violation in Sherwood Park and surrounding areas. Given that everybody in the database committed a traffic offence, this database was utilized to identify the offenders who were stopped during the two campaigns.

The Justice Online Information Network (JOIN) is an Albertan provincial court online information database which collects and stores information pertaining to court appearances criminal convictions, fines, and offender status (Legislative Assembly of Alberta, 2011; Edmonton Police Service, 2019). Police services across Alberta utilize JOIN to perform police record checks as this system records a person's interaction with the legal system (Edmonton Police Service, 2019). The JOIN database was utilized to collect data on whether an offender committed any traffic violation in the last two years including the number as well as type of traffic violation.

Data pertaining to traffic collisions were collected from the Police Reporting and Occurrence System (PROS). The Police Reporting and Occurrence System (PROS) is an RCMP

operated data warehouse that records and manages information pertaining to police occurrences, such as traffic collisions, in Canada (Termium Plus, 2009; Royal Canadian Mounted Police, 2005). As such, PROS was used in order to extract data on a driver's collision history.

Lastly, we extracted the median household income by postal codes (first three digits) by merging our final dataset with the 2016 Canadian Census. Data pertaining to the 2016 Canadian Census was extracted from the University of Alberta library database.

2.3.3 Ethics

Ethics to collect administrative data from the Strathcona county Enforcement services and to conduct this project was approved by the University of Alberta (study ID: Pro00088817).

2.3.4 Data Extraction Strategy and Quality Assessment

Once ethics was approved initially, a trained analyst with the Enforcement services, who had extensive experience working with these databases, created two datasets stored in an excel format. The first data set contained every offender (92,322) who was pulled over by enforcement services in 2017 in Sherwood Park (Appendix A). This dataset contained individuals who chose to receive a fine and those who completed the Option 4 workshop. The option to participate in Option 4 was only provided to offenders who were stopped during the two campaigns dates. The second dataset only contained offenders who both participated and completed the Option 4 workshop (Appendix A).

Next, a new dataset was created, from dataset 1, that filtered for offenders who committed a violation in the months during the first (May 1st, 2017 to May 22nd, 2017) or second campaign (September 25th, 2017 to October 14th, 2017) (Appendix A). This new dataset was then merged with data set 2 using a citation number ID which is a unique ID given to an offender who committed a violation (Appendix A). Prior to merging the two datasets, the Option 4 spreadsheet

contained a column ("Intervention") that had all cells filled in with the term "Option 4". In the merged data set, blank cells in the intervention column would signify which fine group (choice or mandatory) each offender belong to based on the date that they were stopped. That is, offenders who committed any violation between May 1st to May 13th or September 25th to October 7th were classified in the "fine(mandatory)" group while, offenders who committed any violation between May 14th to 22nd or October 8th to October 14th were categorized in the "fine(choice)" group. Offenders that had the "Option 4" term where those who participated and completed Option 4. From this dataset, there were 260 rows that had duplicate rows or other erroneous values and as such were deleted (Appendix A). After duplicates were removed, 1,736 unique offenders were left in the dataset (Appendix A). Enforcement services would enter the pertinent information using the Enforcement Services Records Management System, JOIN, and PROS databases. Once all data had been entered, the enforcement services team would then send that data to us. After we received the data, 29 offenders had non-Albertan postal codes and as such were deleted bringing our total sample size down to 1,707 (Appendix A). To collect our median household income and residence data we merged the 2016 Canadian census with the final data set using the first three digits of offender's postal code (Appendix A). Offenders that had a zero as a second digit in their postal code would be classified as living in rural areas while the remaining offenders would be classified as urban.

For our current study, the control group (fine-mandatory) of traffic offenders (n = 584) who committed any traffic violation outside of the campaign dates (May 1st to May 13th; September 25th to October 7th), were removed and not included in this study as they were not given the opportunity to participate in an Option 4 workshop. They were however retained for

future studies (Chapter 3 and 4). As such, our final sample size for the current study were 1,123 Albertan offenders.

To minimize data entry errors, prior to being sent data back to us a second team member manually checked 10% of randomly chosen records to ensure data entry was accurate. Once data was confirmed to be accurate the data was sent back to us. After all data had been collected, we did a final check to ensure that there were no duplicate rows and that the information that was accurate.

2.3.5 Variables

Dependent Variables

The main outcome variable for this study was a dichotomous variable indicating whether offenders chose to receive a fine or participate in the Option 4 workshop (0 = *Fine*, 1= *Option 4*).

Predictor Variables

Predictor variables including age, area median income, geography of residence, law enforcement campaign, sex, as well as total number of all violations and collisions in the past two years were analyzed. Demographic predictors and variables related to driving were selected based on prior literature (Barrett, 2018; Harano & Peck, 1972; Kloeden & Hutchinson, 2006). For more information on how these variables were coded please see Appendix B.

2.4 Data analysis

2.4.1 Statistical Analysis

The Statistical Analysis System (SAS) software (Version 9.4) was used for all statistical analyses (SAS Institute Inc, 2016). The statistical significance cut-off was established at $p < 0.05$.

2.4.2 Procedures

To assess the bivariate associations between the predictors and choice of participating in Option 4 or receiving a fine, Chi-square and Fisher exact tests were conducted on our categorical variables and a t-test on our continuous variable (age). For variables that violated one or more Chi-square test assumptions (i.e. expected values less than 5) Fisher's Exact tests were conducted. Univariate and multivariate logistic regression models were created in order to determine what predictors are associated with preference regarding receiving a fine or participating in Option 4. Prior to model building, collinearity was assessed using Variance Inflation Factor (VIF). We employed purposeful selection methodology in order to create a parsimonious multivariate logistic regression model. An advantage of purposefully building statistical models is in identifying, incorporating, and controlling for variables that would be considered confounders but would be removed when using forward or backward stepwise methods (Bursac et al., 2008).

As such, several steps were undertaken in order to build our multivariate models. First, we fit univariate logistic regression models with each predictor and our outcomes of interest (Bursac et al., 2008). Results obtained from these analyses were reported as odds ratios (OR) in Table 2. At this stage, variables with p-values less than 0.20 were selected as candidate variables to be included in the final logistic model (Bursac et al., 2008). Variables with p values above 0.20 but considered important to control for based on prior literature, were kept while variables with p values above 0.20 and not considered important based on prior literature were removed (Bursac et al., 2008). Next, a Wald test was employed for each selected variable to assess significance (Bursac et al., 2008). Based on these analyses, two models were built; a full model that included all the variables found non-significant and significant by the Wald tests and a

reduced model that only included the significant variables (Bursac et al., 2008). Confounding effects of these models were checked by calculating the change in coefficients between the two models (Bursac et al., 2008). Changes in 15% or more in any of the coefficients would suggest confounding and thus the full model would be retained whereas changes less than 15% would suggest non-confounding in which case the reduced model would be used instead (Bursac et al., 2008). To ensure whether age was linear, the linear assumption of the age variable was assessed by plotting on a linear line graph and age was visually inspected. If age was not considered linear, then age would be converted to a categorical variable.

2.5 Results

2.5.1 Demographic and descriptive results

A frequency table was created (Table 1) that describes the frequencies and proportions of offenders who either participated in the Option 4 workshop (n = 410) or who opted to receive a fine (n = 713) by our predictors of interest. Additionally, Table 1 shows the results of the chi-square and fisher exact tests as well as the t-tests between the 410 offenders who decided to participate in the Option 4 workshop and the 713 offenders who decided to receive a fine instead.

Table 2.1. Baseline Demographic Characteristics (Study 1)

Demographics	**Education % (n = 410)**	**Fine % (n = 713)**	**Total (n = 1,123)**	**$\chi 2$ (P value)**
Sex				
Male	238 (58.0)	448 (62.8)	686 (61.1)	2.51 (p = 0.11)
Female	172 (42.0)	265 (37.2)	437 (38.9)	
Income [a]				
$48,000-$74,999	31 (7.6)	60 (8.4)	91 (8.1)	
$75,000-$99,999	62 (15.1)	173 (24.3)	235 (20.9)	35.85 (p < 0.0001)
$100,000-$124,999	265 (64.6)	332 (46.6)	597 (53.2)	
> $125,000	52 (12.7)	147 (20.6)	199 (17.7)	
Age*	Mean = 42.8 SD = 16.03	Mean = 38.9 SD = 14.11		
< 19	32 (7.8)	38 (5.3)	70 (6.2)	21.92 (p = < 0.001)
20 – 29	61 (14.9)	181 (25.4)	242 (21.5)	

30 – 39	101 (24.6)	180 (25.2)	281 (25.0)	
40 – 49	83 (20.2)	139 (19.5)	222 (19.8)	
> 50	133 (32.4)	175 (24.5)	308 (27.4)	
Geography				
Urban	409 (99.8)	703 (98.6)	1112 (99.0)	(p = 0.16)
Rural	1 (0.2)	10 (1.4)	11 (1.0)	
Law Enforcement Campaign				
Campaign/Season				
Campaign 1	156 (38.0)	401 (56.2)	557 (49.6)	34.46 (p < 0.0001)
Campaign 2	254 (62.0)	312 (43.8)	566 (50.4)	
Driver history in past two years				
Prior speeding violation				
0	326 (79.5)	522 (73.2)	848 (75.5)	6.63 (p = < 0.05)
1	55 (13.4)	112 (15.7)	167 (14.9)	
> 2	29 (7.1)	79 (11.1)	108 (9.6)	
Prior failure to stop violation				
0	377 (92.0)	707 (99.2)	1084 (96.5)	(p < 0.0001)
1	32 (7.8)	6 (0.8)	38 (3.4)	
> 2	1 (0.2)	-	1 (0.1)	
Prior distracted violation				
0	385 (93.9)	691 (96.9)	1076 (95.8)	(p < 0.05)
1	25 (6.1)	17 (2.4)	42 (3.7)	
> 2	-	5 (0.7)	5 (0.4)	
Prior other driving violation				
0	392 (95.6)	641 (89.9)	1033 (92.0)	12.12 (p = < 0.01)
1	16 (3.9)	57 (8.0)	73 (6.5)	
> 2	2 (0.5)	15 (2.1)	17 (1.5)	
Total prior violations				
0	274 (66.8)	478 (67.0)	752 (67.0)	7.09 (p = < 0.05)
1	91 (22.2)	124 (17.4)	215 (19.1)	
> 2	45 (11.0)	111 (15.6)	156 (13.9)	
Prior collisions				
0	406 (99.0)	694 (97.3)	1100 (98.0)	3.70 (p = < 0.05)
1	4 (1.0)	19 (2.7)	23 (2.0)	

[a]2 individuals had postal codes in which Census Canada had no income information on and as such were deleted here; * Student t-test < 0.05.

A substantially higher number of males (61%) were stopped in both campaigns and were thus overrepresented in both the education (58%) and fine (63%) groups. Over half of offenders were either in their thirties (25%) or fifties and above (27%). About one-third of offenders (32%)

who chose to participate in the option 4 workshop were 50 and above, while over half of offenders who chose to receive a fine were offenders in their twenties (25%) and thirties (25%). Additionally, only one percent of offenders lived in rural communities while over half (53%) lived in communities where the median household income was between $100,000 and $124,999.

Lastly, an equal number of offenders (50%) participated in both the first and second campaigns. Yet, more offenders in the first campaign chose a fine, compared to offenders who chose Option 4 (56% vs. 38%, respectively). In contrast, during the second campaign, more offenders chose Option 4 compared to a fine (62% vs. 44%, respectively). While the majority (67%) did not commit a violation or get involved in a traffic collision (98%), a quarter of the sample (25%) committed at least one speeding violation within two years of being stopped during one of the enforcement campaigns. A higher percentage of traffic offenders who committed one traffic violation in the last two years chose to participate in Option 4 programming than receive a fine (22% vs. 17%, respectively). Offenders that committed two or more violations (16%) or who had a collision in the last two years (8%) decided to receive a fine rather than participate in an Option 4 workshop.

Chi Square tests for homogeneity, Fisher's exact tests, and t-tests found statistically significant differences ($p < 0.05$) between the two groups of offenders regarding median household income, age of the offender, Campaign/Season and all variables related to driver history of violations and collisions. Sex and geography of residence were not associated with choice of Option 4 vs. fines.

2.5.2 Results from logistic regression analysis

In addition to addressing our main objective regarding whether female offenders and offenders under the age of 20 were more likely to participate in Option 4 programming, we were

also interested in determining whether committing one violation versus two or more ("total prior violations") as well as whether committing specific violations such as speeding or distracted driving, defined as binary variables, were associated with choice of education vs. fines relative to offenders who didn't commit these violations. That is, are offenders who are high offenders (> 2) more likely to want to receive a fine versus offenders who are low (1) or non-offenders (0) (see Watson et al., 2015). After examining VIF values, the "total prior violations" variable showed collinearity and the model had poor model fit given our significant p values ($p < 0.05$) after assessing model fit using the Hosmer-Lemeshow test. To correct for this, we removed the "total prior violations" variable from our model and reassessed our model and found no collinearity and non-significant ($p > 0.05$) Hosmer-Lemeshow p-values which indicated that the final model fit the data well. The linear assumption of our continuous variable (i.e. age) was also violated and as such age was transformed into a categorical variable (see Table 1). The unadjusted and adjusted odds ratios, based on our results from the univariate and multivariate logistic regression models, along with their corresponding 95% confidence intervals are displayed in Table 2.

Table 2.2. The results from univariate and multivariable logistic regression analysis: Predictors associated with Option 4 workshop attendance (n = 1,123)

Demographics	**Education (%)**	**Fine (%)**	**OR (95% CI)**	**AOR (95% CI)**
Sex				
Male	238 (58.0)	448 (62.8)	Reference	Reference
Female	172 (42.0)	265 (37.2)	1.22 (0.95, 1.57)	1.21 (0.93, 1.58)
Median Area Income				
$48,000-$74,999	31 (7.6)	60 (8.4)	1.46 (0.85, 2.50)	1.48 (0.84, 2.62)
$75,000-$99,999	62 (15.1)	173 (24.3)	1.01 (0.66, 1.56)	1.09 (0.69, 1.73)
$100,000-$124,999	265 (64.6)	332 (46.6)	2.26*** (1.58, 3.22)	2.49*** (1.70, 3.64)
> $125,000	52 (12.7)	147 (20.6)	Reference	Reference
Age				

< 19	32 (7.8)	38 (5.3)	1.1108 (0.66, 1.87)	1.33 (0.76, 2.34)
20 – 29	61 (14.9)	181 (25.4)	0.44*** (0.31, 0.64)	0.47** (0.32, 0.69)
30 – 39	101 (24.6)	180 (25.2)	0.74 (0.53, 1.03)	0.74 (0.52, 1.06)
40 – 49	83 (20.2)	139 (19.5)	0.79 (0.55, 1.12)	0.75 (0.52, 1.10)
> 50	133 (32.4)	175 (24.5)	Reference	Reference
Geography				
Urban	409 (99.8)	703 (98.6)	5.82 (0.74, 45.61)	3.32 (0.40, 27.46)
Rural	1 (0.2)	10 (1.4)	Reference	Reference
Law enforcement campaign				
Campaign/Season				
Campaign 1	156 (38.0)	401 (56.2)	Reference	Reference
Campaign 2	254 (62.0)	312 (43.8)	2.09*** (1.63, 2.68)	2.16*** (1.63, 2.85)
Driving History (Last 2 Years)				
Prior Collisions				
0	406 (99.0)	694 (97.3)	Reference	Reference
1	4 (1.0)	19 (2.7)	0.36 (0.12, 1.07)	0.36 (0.10, 1.21)
Prior violations committed in the last 2 years				
Speeding	84 (20.5)	191 (26.8)	0.70* (0.53, 0.94)	0.91 (0.65, 1.26)
Distracted	25 (6.1)	22 (3.1)	2.04* (1.14, 3.67)	2.52** (1.32,4.82)
Other	18 (4.4)	72 (10.1)	0.41** (0.24, 0.70)	0.49* (0.28, 0.87)
Failure to Stop	33 (8.0)	6 (0.8)	10.31*** (4.28, 24.84)	11.85*** (4.73, 29.73)

Notes. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.0001$.

The unadjusted models show that offenders in their twenties (Odds Ratio OR = 0.44, 95% CI: 0.31, 0.64), those who committed a speeding offence (OR = 0.70, 95% CI: 0.53, 0.94) and/or violation classified as "other" (OR = 0.41, 95% CI: 0.24, 0.70) two years prior exhibited lower odds of choosing to participate in Option 4 than their counterparts. The directionality remained the same for all significant variables. The unadjusted odds ratios confirmed that

offenders who participated in the second campaign (OR = 2.09, 95% CI: 1.63, 2.68), committed a distracted driving (OR = 2.04, 95% CI: 1.14, 3.67), and/or a failure to stop at a stop sign (OR = 10.31, 95% CI: 4.28, 24.84) violation in the last two years were more likely to participate in an Option 4 workshop than receive a fine. The significance level of the previous mentioned variables remained unchanged in the multivariate logistic model except for those who committed a speeding violation in the last two years.

After controlling for our predictors, offenders who lived in communities where the median household income was between $100,000 and $124,999 were 2.49 times (p <0.05) more likely to participate in the Option 4 workshop than offenders who lived in communities where the median household income was greater than $125,000. While the odds ratio showed that females and those living in urban communities were more likely to participate in the Option 4 workshop, the unadjusted and adjusted odds ratios were non-significant (p > 0.05) contrary to our hypothesis. Offenders who were caught committing a violation during the second campaign/fall season (AOR = 2.16, 95% CI: 1.63, 2.85) were also more likely to participate in Option 4 than to receive a fine.

2.6 Discussion

Prior research has speculated that various behavioral, geographic, and social factors can influence one's proclivity to participate in educational workshops as opposed to receiving fines (Barrett, 2018; Harano & Peck, 1972; Kloeden & Hutchinson, 2006). Our study confirmed these studies by identifying various environmental, demographic and, driver predictors of workshop attendance. Unlike Kloeden and Hutchinson's (2006) evaluation of a DIP in Australia, and in contrast to our hypothesis, female offenders and those under the age of 20 were not statistically more likely to participate in the workshop after controlling for our predictors while offenders in

their twenties were less likely to choose to attend Option 4 workshop than those who were 50 or older. We can speculate that offenders in their twenties may have less leisure time than offenders who are 50 and above thereby limiting their availability and ability to attend Option 4 workshops. However, our study did find additional factors, not previously reported, that predicted choice of participating in a DIP, including living in communities where the median income was $100,000 to $124,999 when compared to those who lived in a community where the median household income was greater than $125,000. Unlike Finland, which operates on a day-fine system where traffic fines are tied to one's income, Alberta operates on a demerit-based system where everyone pays the same amount regardless of income (Government of Alberta, 2020; Kantorowicz-Reznichenko, 2015). As observed in Barret's (2018) evaluation, who found avoidance of fines as the most common reason to attend a DIP, offenders living in middle-class areas could have been more motivated to avoid paying fines when compared to offenders who lived in higher-income areas (Barret, 2018). Offenders living in higher-income neighbourhoods may have more income flexibility in choosing whether to pay their fines or spend time attending a workshop compared to offenders living in middle-class communities (Piff et al., 2012). However, the current study did not measure motivation to participate in Option 4 using qualitative or survey methodologies. As such, we cannot confidently attribute differences in workshop participation between the different income groups to either fine avoidance or higher income flexibility (Barret, 2018; Piff et al., 2012).

The more interesting and never prior explored differences was regarding driver history. Offenders who committed one or more distracted driving violations and/or failure to stop at a stop sign violations were more likely to participate in the Option 4 workshop compared to offenders who didn't receive those citations in the last two years; offenders who committed a

violation labeled as “other” were less likely to participate in Option 4. These differences can potentially be attributed to the focus and goal of the two campaigns. After committing a traffic violation, offenders were informed by enforcement officials on the topics that would be discussed in the Option 4 workshop ahead of time. Since the second campaign was focused on stop sign compliance, it is likely that offenders who committed violations other than stop sign compliance or distracted driving may not have seen the value in attending these sessions as they were informed about the content and topics that the Option 4 workshops would cover. However, our other findings challenge this interpretation. Our unadjusted model showed that offenders who were speeding were more likely to receive a fine. Additionally, our adjusted model showed that offenders who were caught committing a distracted driving offense were more likely to participate in Option 4. As such, another interpretation can be attributed to offenders’ misinformation regarding traffic safety. According to feedback from participants who attended the Option 4 workshops during the second campaign, almost half (42%) had thought they had fully stopped at a stop sign while 15% thought that they didn’t need to stop (Rawson, 2018). A pilot study focused on educating American teenagers on the dangers of using cellphones while driving found that most teenagers were unaware of laws regarding cell phone use and almost all thought that they were safe offenders (Unni et al., 2013). These findings suggest that offenders who had a history of committing distracted driving or failure to stop at stop-sign violations may have been unaware of the laws regarding those violations and may have been more motivated to educate themselves on general traffic safety. A vast majority of offenders who committed speeding and or other violations may have been aware that their driving behaviours were dangerous given that only 24% indicated that they were unaware they were in a school zone or that the school zone was in effect when stopped during the first campaign (Rawson, 2017). As

such, these traffic offenders may have been less motivated to participate in the Option 4 workshops as a result. However, given that the current study failed to incorporate driver perceptions surrounding traffic offenses or why they chose to participate in an Option 4 workshop or receive a fine, these observations are speculative.

Despite our speculative interpretations of the findings, our exploratory study nonetheless stimulated discussions regarding what characteristics may be associated with choosing to participate in a traffic education workshop (i.e. Option 4) or receive a traffic fine. Harano & Peck (1972) noted that the effectiveness of the educational curriculum that they were evaluating, as opposed to those just receiving a fine, was highly affected by the demographic and other characteristics of the offenders who attended the course. Interestingly, traffic offenders who completed a traffic workshop in the United States had higher or similar rates of violations or collisions than traffic offenders who did not complete a workshop (Gebers, 2010; Villaveces et al., 2011). Conversely, traffic offenders in Britain and Australia who completed a traffic workshop had lower violations than those who decided to receive a fine (Barrett, 2018; Kloeden & Hutchinson, 2006; Wåhlberg, 2010). One interpretation can attribute these differences to demographic differences between samples in the United States and those in Australia and Britain while another interpretation can attribute the differences to the fact that the Australian and British samples were given the choice to participate in the interventions, suggesting that motivation to participate in educational workshops had an impact on reducing future violation and collision risk rather than the interventions themselves. Thus, assessing motivation to participate in traffic safety workshop is an important factor to consider and control for when evaluating future Option 4 or other traffic safety workshops.

2.7 Study Limitations

Various limitations are present in the current study. Our study failed to incorporate several important variables such as miles traveled, the number of years that offenders were licensed for, demerit points, and how fast offenders were traveling (Barrett, 2018). The inclusion of these predictors could have resulted in different results. Failure to include these predictors was due to data unavailability.

Additional limitations, present in the current study, may have also contributed to information bias. First, all data was manually entered by the Strathcona Enforcement team and could have resulted in data entry errors. Secondly, there is a risk that offenders may have committed traffic violations or been involved in collisions in other non-Albertan jurisdictions in the past. Data regarding these types of events would not be collected by the PROS or JOIN databases and thus not incorporated in the analysis.

Despite the limitations, the PROS and JOIN databases contain the most up to date and complete traffic information for all licensed Albertan offenders. Additionally, the PROS and JOIN databases are routinely used by police departments in the province to assess for violation history. To minimize data entry errors, a second-team member randomly checked 10% of entered records to ensure data entry was accurate and contained no data entry errors.

2.8 Conclusion

This is the first Canadian study, to our knowledge, to investigate predictors of traffic safety workshop attendance using a sample of traffic offenders. The results of this study found a diversity of factors influencing Option 4 attendance including, income, age, driver history, as well as season. Future research will need to incorporate the aforementioned factors and other potentially important predictors when evaluating the effectiveness of Option 4 or other DIP

programming. Similar to other research, the current findings can assist stakeholders in finding new ways of enhancing workshop attendance (Bowman et al., 2016; Fleming et al., 2015; Williams et al., 1998). Law enforcement personnel seeking to increase attendance of Option 4 or other DIP programming can use the findings from this study to tailor their marketing strategies based on groups who are motivated to attend Option 4 programming (i.e. older offenders, living in areas where the median income is between $100,000 - $124,000, and those who committed distracted driving and failure to stop at stop signs in the past two years) and those who are not (i.e. offenders in their twenties and those who committed other driver violations). By differentiating the messaging regarding the purpose and benefit of DIPS to these two populations, law enforcement services and agencies can potentially increase buy in and motivation of traffic offenders to attend workshops who would otherwise choose to receive a fine. Subsequent research can also interview both populations to assist agency efforts in modifying how the messaging of Option 4 should be presented to these various groups by identifying an offender's motivation to attend or not attend workshops and factors that would increase their interest (Barret, 2018). Despite the limitations present, this study is a steppingstone for future work interested in enhancing offender participation in educational workshops which, could lead to safer roads.

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Chapter 3: Does participation in a driver education program reduce risk of subsequent traffic violations?

3.1 Introduction

Traffic violations are driving behaviors that deviate from traffic laws imposed within a given jurisdiction and are a strong predictor of traffic collisions (Davis et al, 2018; Factor, 2014; Ross, 1960; Vardaki & Yannis, 2013). As such, efforts focused on reducing traffic violations can reduce risky driving behaviors among drivers as well as future fatalities and injuries due to motor vehicle collisions (Zhang et al., 2013).

Interventions designed to reduce traffic violations have varied but generally consist of either law enforcement or educational interventions. Both law enforcement and educational interventions are designed to alter the behaviours of drivers to encourage safer driving practices and greater compliance with traffic laws (Wåhlberg, 2010, 2011, 2013). Typically, law enforcement interventions can vary in severity and frequency, ranging from less common, but more severe punishments (e.g., imprisonment) to less severe but more common tactics such as imposing monetary fines on drivers (Ross, 1960). Enforcement interventions assume the operation of a specific or general deterrence mechanism so that drivers become fearful of being punished (Davey & Freeman, 2011; Stafford & Warr, 1993; Walter & Studdert, 2015). In contrast, educational programs, otherwise known as Driver Improvement programs (DIP), are designed to promote and teach safe driving behaviors for first-time and problematic offenders so that they become safer drivers (Struckman-Johnson, et al., 1989; Wåhlberg, 2013; Zhang et al., 2011). Yet, most studies investigating each type of intervention approach have been evaluated independently, with only a few evaluations comparing the relative effectiveness of DIPs vs. fines.

Arriving at a definitive conclusion as to whether educational interventions are effective is complex as some studies have found them ineffective in reducing the risk of future violations. A study evaluating an American DIP that compared a group of drivers who participated in an educational workshop to a group that did not, found that the workshops did not reduce the risk of future violations (Villaveces et al., 2011). It was unknown whether the unexposed grouped experienced other penalties in addition to fines (Villaveces et al., 2011).

However, other studies have found these DIPs as beneficial in promoting traffic safety when compared to offenders who received fines. Most of the work conducted on evaluating the effectiveness of educational workshops has largely been conducted in England (Barrett, 2018; Burgess & Webley, 1999; Conner & Lai, 2005; Wåhlberg, 2010, 2011, 2013). The National Driver Improvement Scheme (NDIS) also known as the National Driver Offender Retraining Scheme (NDORS) is a national British driving program that was incorporated in the 1990s which provides recidivist drivers the opportunity to attend educational workshops, focused on teaching safer driving skills, in lieu of being punished with fines and other penalties (Hibberd, 2013). One evaluation on the NDIS program found that drivers who were referred to a course after committing a careless driving offence had modestly improved attitudes regarding safe driving one year after completing the program, compared to a control group, who also committed a careless offence but who weren't referred to the NDIS program with no improvement in driving ability (Conner & Lai, 2005). Another evaluation found that those who participated in the NDIS had a reduction in the number of violations that they committed after completing the course (Burgess & Webley, 1999). A third evaluation, focused on assessing the National Speed Awareness course, a workshop teaching drivers compliance with local speed limits as opposed to punishing them, found the course more effective in decreasing speeding violation recidivism

when compared to a group who received a fine (Barrett, 2018). Similar to the aforementioned evaluations, a series of studies conducted by Wåhlberg (2010; 2011; 2013) on British driver improvement schemes also confirmed the above-mentioned results. Wåhlberg (2010) evaluated the Young Driver Scheme (YDS) online program which allowed young drivers (< 25 years of age) in England, convicted of a traffic offence, to attend a traffic safety workshop rather than pay fines associated with their offence. Drivers who completed the course reported higher levels of aggression and driving violations six months after taking the course (Wåhlberg, 2010). Wåhlberg (2010) did report, however, that drivers were more honest about committing traffic violations than the fine-only comparison group in future waves, suggesting that there were some positive effects of exposure to the course. Wåhlberg (2011) compared drivers taking an instructional/classroom based educational program, specifically focused on changing behaviours associated with speeding, with drivers who participated in the YDS online program and drivers who were only fined and had taken a previous educational workshop before. Wåhlberg (2011) concluded that the YDS group had lower traffic offences six months after taking the course while the same findings were not found among drivers who took a lecture classroom-based workshop and those who were only fined. Wåhlberg (2011) also noted that participants in the YDS course experienced the greatest changes in relation to driving behaviours than the other groups. Lastly, Wåhlberg, (2013) assessed a group who, rather than paying a fine, chose to complete an educational program designed for seat belt compliance. The results of the evaluation showed that drivers who completed the course had greater compliance with seat belt use three months after completing the course (Wåhlberg, 2013). Finally, Harano and Peck (1972) utilized an experimental design where drivers were assigned to either attend group meetings as part of an educational curriculum or a control group who did not undergo the educational programming and

instead only had to pay a fine by a judge. The researchers randomly selected the drivers into their study (Harano & Peck, 1972). The authors found that the group who completed the driving curriculum had a lower driving conviction risk than those who simply paid their fines (Harano & Peck, 1972).

To our knowledge only one Australian evaluation has been conducted to investigate the effectiveness of educational workshops as compared to fines. Kloeden and Hutchinson (2006) evaluated a sample of young adult Australian drivers who were given the option to take a DIP, a 90 minute small-group interactive workshop designed for young adults (< 25), after committing a traffic violation rather than pay an expiation fee, or fine, by mail. Traffic offence rates were assessed 1 to 18 months after taking the course and compared with a group who decided to pay a fine and not attend the workshop (Kloeden & Hutchinson, 2006). The authors found that the DIP group had substantially fewer administrative violations (failure to wear seat belts, driving an unregistered car, failure to have a license, unlicensed driving), and slightly fewer driving violations (drinking and driving, speeding, performing illegal turns, or disobeying traffic signals or failure to stop at stop signs) after taking the course, compared to the group that only paid a fine (Kloeden & Hutchinson, 2006). However, both groups had higher frequencies of traffic offences 18 months after completing the course or paying a fine than their baseline figures, suggesting an association between participation in educational workshops and short-term reductions in future traffic violations (Kloeden & Hutchinson, 2006). Lastly, other research incorporating various analytic approaches including survival analysis or binary probit models also found that various DIP modalities were effective in reducing future likelihood and frequency of traffic violations (Jones 1997a, 1997b; Raub et al., 1999; Zhang et al., 2011).

While these prior studies suggest that educational interventions are more effective in reducing risk of committing subsequent violations, several knowledge gaps currently exist in the literature. First, previous research considered only driving-related covariates as potential confounding variables. Currently, no evaluation has included or controlled for community-level predictors, such as area median income or whether the offender lives in an urban or rural area, which may have also played a role in influencing future violations. Finally, no current evaluations have been conducted on a Canadian and/or Albertan sample of offenders. The present study addresses all of these knowledge gaps. Our objective was to determine whether the incidence of subsequent violations was lower in the education group than in the fine group before and after controlling for potential confounders. Based on prior literature, we hypothesize that participating in a DIP (Option 4) led to slower time to subsequent violation and decreased risk in future traffic violations compared to those who only received a fine instead (Barrett, 2018; Harano & Peck 1972; Kloeden & Hutchinson, 2006; Wåhlberg, 2011).

3.2 Context for the Present Study

Option 4 is a 90-minute DIP that has been implemented in Alberta since 1988 (Narbonne, 2017). The name "Option 4" originates from the three options that are displayed on the back of a violation notice that drivers receive when they are caught committing a traffic violation in Alberta, which are: paying a fine (Option 1), pleading not guilty by mail (Option 2) or in court (Option 3) (Alberta Occupant Restraint Program, 2019). Initially, Option 4 was designed to teach drivers on how to handle and maintain care of child restraints, such as booster seats, child safety seats, etc., as opposed to drivers simply paying a traffic fine (Alberta Occupant Restraint Program, 2019). The Option 4 framework has since expanded to incorporate drivers who were caught committing traffic violations other than misuse of child restraints such as speeding,

failing to stop at a stop sign, among many others (Rawson & Narbonne, 2018). Similar to child restraints, the Option 4 program is used to educate drivers and other vehicle occupants on traffic safety offences (Rawson & Narbonne, 2018). Content for each session not only educates offenders about the legislation surrounding a violation (i.e. speeding or failure to stop at a stop sign) and the Vision Zero philosophy but also about the risks of these violations (Rawson, 2018). Each session is also interactive as it asks attendees how law enforcement personnel can improve traffic safety measures and help officers identify gaps in driver education (Rawson, 2018). Over the years, Option 4 workshops have generally been implemented during various Albertan law enforcement traffic campaigns.

In 2017, Strathcona County's Royal Canadian Mounted Police (RCMP) and Enforcement Services launched two law enforcement campaigns. The first campaign, *Neighbourhood Traffic Safety*, was conducted between May 14th and 22nd, 2017 and focused on addressing residential speeding in and around Sherwood Park (Rawson, 2017). The goal of the campaign and the focus of the Option 4 workshops during this campaign were to heighten awareness among attendees on the risks speeding poses to pedestrians (Rawson, 2017). A second campaign, Stop Sign Safety Campaign, was also held in Sherwood Park in the fall of 2017 (October 8th and October 14th, 2017) (Rawson, 2018). Unlike the first campaign, the second campaign focused on increasing stop sign compliance rather than residential speeding (Rawson, 2018). The campaign and Option 4 workshops focused on heightening awareness regarding stop sign compliance and how offenders should maneuver around stop-controlled intersections (Rawson, 2018). The formats of the workshops were essentially the same with the only difference being the focus of the campaign changing from residential speeding to stop sign compliance (Rawson, 2018). During

both campaigns, offenders who were caught committing any traffic violation were offered the choice of either paying their fine or attending the option 4 program (Rawson, 2017).

3.3 Methods

3.3.1 Study population and design

The study population used for this analysis were Albertan traffic offenders who were pulled over by Peace Officers as well as the Royal Canadian Mounted Police (RCMP), due to committing any traffic violations, during the *Neighbourhood Traffic Safety* and the *Stop Sign Safety Enforcement* Campaigns in Sherwood Park, Alberta in 2017. The *Neighbourhood Traffic Safety* campaign was conducted between May 14th and 22nd, while the *Stop Sign Safety* campaign was conducted between October 8th to October 14th (Rawson, 2017, 2018). The *Neighbourhood Traffic Safety* campaign focused on addressing residential speeding while the *Stop Sign Safety campaign* focused on increasing stop sign compliance in and around Sherwood Park (Rawson, 2017, 2018). During each campaign, all traffic offenders were asked if they were interested in participating in the Option 4 workshop as opposed to receiving a fine. Offenders interested in attending the Option 4 workshop were instructed that upon completion of a workshop, their traffic offence would be reduced to a warning and would not have to pay a fine. These offenders were categorized into an 'Option 4' group. Traffic offenders who chose not to participate in an Option 4 workshop and to receive a fine instead were classified into a "Fine (choice)" group. The study also established a third comparison group of traffic offenders who committed any traffic violation outside of the first (May 1st to May 13th) and second (September 25th to October 7th) campaign dates (Rawson, 2017, 2018). These traffic offenders received a mandatory fine and were not provided the opportunity to participate in an Option 4 workshop and served as a control group for the study, i.e., they were categorized into the "Fine (mandatory)" group. Non-Albertan

offenders, defined as those who both did not have Albertan License plate numbers and Postal Code residences, were excluded from the study.

3.3.2 Data Sources

Data used for this study were contained and linked across several administrative databases, including the Enforcement Services Records Management System, Justice Online Information Network (JOIN), and the Police Reporting and Occurrence System (PROS), and the Remote Office and Dispatch System (ROADS) databases as well as the 2016 Canadian census. All data were accessed, except for the 2016 Canadian census, from Enforcement Services located in Sherwood Park, Alberta.

Data describing demographic characteristics of all offenders were collected from the Enforcement Services Records Management System. The Enforcement Services Records Management System is an in-house data warehouse environment that contains electronic records of offenders who were pulled over by the Sherwood Park enforcement services due to committing a traffic violation in Sherwood Park and surrounding areas. Given that all records in the database committed a traffic offence, this database was utilized to identify offenders who were stopped during the two campaigns.

The Justice Online Information Network (JOIN) is an Alberta provincial court online information database which collects and stores information pertaining to court appearances criminal convictions, fines, and offender status (Legislative Assembly of Alberta, 2011; Edmonton Police Service, 2019). Police services across Alberta utilize JOIN to perform police record checks as this system records a person's interaction with the legal system (Edmonton Police Service, 2019). The JOIN database was utilized to collect data on the number of traffic

violations two years prior to being stopped during one of the campaigns as well as type of traffic violation.

Data on traffic collisions were collected from the Police Reporting and Occurrence System (PROS). The Police Reporting and Occurrence System (PROS) is an RCMP- operated data warehouse that records and manages information pertaining to police occurrences, such as traffic collisions, in Canada (Termium Plus, 2009; Royal Canadian Mounted Police, 2005). As such, PROS was used in order to extract data on an offender's collision history in the past two years.

The Remote Office and Dispatch System (ROADS) is another version of the Computerized Integrated Information Dispatch System (CIIDS) (British Columbia's Radio Scanning Community, 2019). The CIIDS is the primary dispatch system that the RCMP uses to log incidents. ROADS allow users to perform similar data-based queries in ROADS as in CIIDS (British Columbia's Radio Scanning Community, 2019). As such, the ROADS dataset was used in order to determine whether an offender committed a violation within 18 months of receiving a fine or participating in the Option 4 workshop.

Lastly, we extracted the median household income by postal codes (first three digits) by merging our final dataset with the 2016 Canadian Census. Data pertaining to the 2016 Canadian Census was extracted from the University of Alberta library database.

3.3.3 Ethics

Ethics to collect administrative data from the Strathcona county Enforcement services and to conduct this project was approved by the University of Alberta (study ID: Pro00088817).

3.3.4 Data Extraction Strategy and Quality Assessment

Once ethics was approved initially, a trained analyst with the Enforcement services, who had extensive experience working with these databases, created two datasets stored in an excel format. The first data set contained every offender (92,322) who was pulled over by enforcement services in 2017 in Sherwood Park (Appendix A). This dataset contained individuals who chose to receive a fine and those who completed the Option 4 workshop. The option to participate in Option 4 was only provided to offenders who were stopped during the two campaigns dates. The second dataset only contained offenders who both participated and completed the Option 4 workshop (Appendix A).

Next, a new dataset was created, from dataset 1, that filtered for offenders who committed a violation in the months during the first (May 1st, 2017 to May 22nd, 2017) or second campaign (September 25th, 2017 to October 14th, 2017) (Appendix A). This new dataset was then merged with data set 2 using a citation number ID which is a unique ID given to an offender who committed a violation (Appendix A). Prior to merging the two datasets, the Option 4 spreadsheet contained a column ("Intervention") that had all cells filled in with the term "Option 4". In the merged data set, blank cells in the intervention column would signify which fine group (choice or mandatory) each offender belong to based on the date that they were stopped. That is, offenders who committed any violation between May 1st to May 13th or September 25th to October 7th were classified in the "fine(mandatory)" group while, offenders who committed any violation between May 14th to 22nd or October 8th to October 14th were categorized in the "fine(choice)" group. Offenders that had the "Option 4" term where those who participated and completed Option 4. From this dataset, there were 260 rows that had duplicate rows or other

erroneous values and as such were deleted (Appendix A). After duplicates were removed, 1,736 unique offenders were left in the dataset (Appendix A).

Enforcement services would enter the pertinent information using the Enforcement Services Records Management System, JOIN, and PROS databases. Once all data had been entered, the enforcement services team would then send that data to us. After we received the data, 29 offenders had non-Albertan postal codes and as such were deleted bringing our total sample size down to 1,707 (Appendix A). To collect our median household income and residence data we merged the 2016 Canadian census with the final data set using the first three digits of offender's postal code (Appendix A). Offenders that had a zero as a second digit in their postal code would be classified as living in rural areas while the remaining offenders would be classified as urban.

To minimize data entry errors, prior to being sent data back to us a second team member manually checked 10% of randomly chosen records to ensure data entry was accurate. Once data was confirmed to be accurate the data was sent back to us. After all data had been collected, we did a final check to ensure that there were no duplicate rows and that the information that was accurate.

3.3.5 Variables

Dependent Variable

The main outcome variable was a binary variable assessing whether an offender committed a subsequent traffic offence (0 = *No*, 1 = *Yes*) after either receiving a traffic fine or completing the option 4 workshop by the end of the study follow-up period (December 31st, 2018).

Time variable

For offenders in both the Fine (choice) and Fine (mandatory) groups, time in the follow up period was defined as the days from the date they received a fine until their first violation. Regarding offenders who completed the educational workshop ("option 4"), their time was defined as the date they completed the workshop until the date of their first violation. All offenders who did not have an event occur were censored after the follow up date (December 31st, 2018).

Predictor Variables

Predictors were classified into four categories; demographics (sex, age), community (income, residence), past two-year driver history (violations, collisions) and variables pertaining to the interventions (Campaign, Intervention). Demographic predictors and predictors related to driving were selected based on prior literature investigating speeding, stop sign compliance and driving violations in general (Keay et al., 2009; Kim & Kim, 2017; Lawpoolsri et al., 2007; Li et al., 2011; Retting et al., 2003; Villaveces et al., 2011; Woldeamanuel, 2012; Zhang et al., 2013).

Predictor variables were coded at the time that the traffic offender was pulled over during one of the campaign months including age, sex, area median income, and geography of residence. Prior driving history was assessed within two years from the index date that the offender was stopped during one of the campaigns (Li et al., 2011; Oviedo-Trespalacios et al., 2017; Villaveces et al., 2011). Area median income was assessed by matching the postal code of individuals who were ticketed with the 2016 Canadian Census for that postal code area (Li et al., 2011).

Various environmental variables were considered including the day, month, and season of offenders when they were pulled over. Given that not all environmental variables could be

incorporated, due to collinearity and overfitting the model, a variable was created (Campaign/Season) which categorized offenders in either the first (0) or second campaign (1) and included in the model selection procedure. The variable served a twofold purpose. First, the variable would control for the potential bias and effect of combining the data from the two campaigns, given that offenders from the first campaign contributed a substantially larger survival time than those in the second campaign (c.f. Edwards et al., 2020). Secondly, the variable would control for seasonality given that the first campaign was in the spring while the second was in the fall.

3.4 Data Analysis

3.4.1 Statistical Analysis

The Statistical Analysis System (SAS) software (Version 9.4) was used for all statistical analyses while R was used to test for Schoenfeld residuals using the "survival" package (SAS Institute Inc, 2016; Therneau, 2015). The statistical significance cut-off was established at $p < 0.05$. Various studies and other evaluations were referenced for guidance when conducting our analyses (Jones 1997a, 1997b; Lawpoolsri et al., 2007; Li et al., 2011; Raub et al., 1999; Roman et al., 2013; Zhang et al., 2011).

3.4.2 Procedures

Descriptive statistics assessed the percentage of offenders who committed a traffic violation during the one and a half year follow up period. First, we calculated frequencies and percentages of offenders in our fine and education groups by our predictor variables of interest. We also conducted Chi-Square and Fisher exact tests for categorical predictors and student t-tests for our continuous variable (i.e. age) to test for bivariate associations between our predictors and offenders who completed the Option 4 workshop and offenders who received the fine. For

variables that violated one or more Chi-square test assumptions (i.e. expected values less than 5, etc) Fisher's Exact tests were conducted.

Survival analyses were then conducted in order to assess differences in time to subsequent violations between Option 4 participants and fine group before and after controlling for potential confounders. Kaplan-Meier curves were used to visualize the effects of education and fine group on this outcome as well as among age groups and sex of the offender (i.e. violation risk) (Li et al., 2011). In order to statistically test whether survival varied between the two groups, log-rank tests were employed (Li et al., 2011). The treatment variable was converted from a trichotomous to a binary variable by collapsing the two fine groups ("Fine-Choice" and "Fine-Mandatory") into one group (Fine/control) to better facilitate analysis. Prior to model building, collinearity was assessed using Variance Inflation Factor (VIF) and revealed that collinearity existed when incorporating "total prior violations" and the individual violation variables (i.e. prior speeding, failure to stop violation, distracted driving, and other violations). As such, only the "total prior violations" was incorporated which categorized whether offenders had no violations (0), one violation (1), two or more violations (>2) two years prior to being stopped (Li et al., 2011; Villaveces et al., 2011). Keeping this variable and eliminating the other driving variables avoided collinearity and overfitting the final multivariate Cox's model. Age was used as a continuous rather than a categorical variable as it met the linear assumption.

After modeling time to subsequent violations between groups, univariate and multivariate Cox's proportional hazards models were fitted. We utilized a purposeful selection methodology to create a parsimonious multivariate Cox's proportional hazard model to address our objective (Bursac et al., 2008). Interactions found to be significant, using the Wald test, were incorporated in the final Multivariate Cox's proportional model (Bursac et al., 2008). Hazard ratios and their

corresponding 95% confidence intervals were computed using the profile likelihood method given its greater accuracy than the Wald Method (Allision, 2010).

After the final multivariate Cox's proportional model was built, the proportional hazards (PH) assumption for the final main effect and interaction multivariate model, as well as for each predictor variable, was assessed via three methods. We first assessed proportionality using the Schoenfeld residual global test (Therneau, 2015). A non-significant global test and individual p values ($p > 0.05$) would indicate that the proportional hazards assumption was met, given a lack of statistical interaction with time (Therneau, 2015). Secondly, Martingale residuals were conducted to test for non-proportionality using methods originally explored by Lin et al. (1993) (Allison, 2010). Similar to the Schoenfeld residuals, non-statistical p values for each variable would indicate that the PH assumption has been met (Allison, 2010). Finally, to assess whether each variable included in our study met the proportional hazards assumption, each predictor and their categories were first plotted on a log minus log (LML) plot to assess interactions with time. Visual inspections of each plot would indicate non-proportionality. However, in order to statistically test whether non-proportionality was met, each predictor would be assessed with time as the outcome (Allison, 2010). Non-significant p values ($p > 0.05$) would indicate that the PH assumption had been met (Allison, 2010). If all three methods yielded non - significant p values, we would confirm that the PH assumption has not been violated and we could proceed with reporting the results from survival analyses.

3.5 Results

3.5.1 Demographic and descriptive results

1,707 Albertan offenders, who were stopped during the two enforcement campaigns, were included in this study (Table 3.1). Of those 1,707 offenders, 410 offenders chose to

complete an Option 4 workshop in lieu of paying their traffic fine, while 713 offenders chose to receive a fine instead of participating in an Option 4 workshop (Table 3.1). An additional 584 offenders were also selected to serve as a control group as they were not given the opportunity to participate in Option 4 (Table 3.1). The demographics of offenders as well as the Chi-Square tests and t-tests between our three groups and predictors are described in Table 3.1. Most (62%) of offenders who were stopped during the campaigns were male whereas just over a quarter of offenders (27%) were fifty years or older (Mean = 39.9, Median = 38, SD = 14.77, Range = 16 - 91); Table 3.1). Over half of participants (51%) lived in communities where the median household income was between $100,000 and $124,999 and only 1% lived in rural communities (Table 3.1). The vast majority of offenders did not commit a speeding (73%), failure to stop (97%), distracted (96%) or other (90%) driving violation two years before being stopped in one of the campaigns while only 2% of offenders had a collision within two years of being stopped during one of the campaigns (Table 3.1). Chi-square, Fisher exact, and student t-tests confirmed statistically significant ($p < 0.05$) demographic differences such as age and area income as well as law enforcement campaigns and prior history of all violations between offenders of all groups (Table 3.1). Lastly, 35% of offenders had a follow up violation after either receiving a fine or completing the Option 4 workshop (Table 3.1). Statistically significant ($p < 0.05$) differences were observed between offenders of all groups with offenders in the two fine groups (Fine-choice, fine-mandatory) committing more follow up violations (38%, 41%, respectively) than offenders in the Option 4 (Education) group (19%) (Table 3.1).

Table 3.1. Baseline Demographic Characteristics (Study 2)

Demographics	**Education (*n* = 410)**	**Fine (Choice) (*n* = 713)**	**Fine (Mandatory) (*n* = 584)**	**χ2 (P value)**	**Total (*N* = 1,707)**
Sex					
Male	238 (58)	448 (62.8)	366 (62.7)	2.93	1052 (61.6)
Female	172 (42)	265 (37.2)	218 (37.3)	(p = 0.23)	655 (38.4)

Age*	Mean = 42.8 SD = 16.03	Mean = 38.9 SD = 14.11	Mean = 39.2 SD = 14.39		
< 19	32 (7.8)	38 (5.3)	32 (5.5)		102 (6.0)
20 – 29	61 (14.9)	181 (25.4)	147 (25.2)		389 (22.8)
30 – 39	101 (24.6)	180 (25.2)	143 (24.5)	24.64	424 (24.8)
40 – 49	83 (20.2)	139 (19.5)	113 (19.3)	(p < 0.01)	335 (19.6)
> 50	133 (32.4)	175 (24.5)	149 (25.5)		457 (26.8)
Area median Income**					
$48,000 - $74,999	31 (7.6)	60 (8.4)	50 (8.6)		141 (8.3)
$75,000 - $99,999	62 (15.1)	173 (24.3)	147 (25.2)	42.69	382 (22.4)
$100,000 - $124,999	265 (64.6)	332 (46.6)	272 (46.6)	(p < 0.0001)	869 (50.9)
> $125,000	52 (12.7)	147 (20.6)	114 (19.5)		213 (18.3)
Residence					
Rural	1 (0.2)	10 (1.4)	9 (1.5)	4.06	20 (1.2)
Urban	409 (99.8)	703 (98.6)	575 (98.5)	(p = 0.13)	1687 (98.8)
Law enforcement campaign					
Campaign/ Seasons					
Campaign 1	156 (38)	401 (56.2)	432 (74)	129.01	989 (57.9)
Campaign 2	254 (62)	312 (43.8)	152 (26)	(p < 0.0001)	718 (42.1)
Driving History (Last 2 Years)					
Prior speeding violation					
0	326 (79.5)	522 (73.2)	402 (68.8)	15.95	1250 (73.2)
1	55 (13.4)	112 (15.7)	118 (20.2)	(p < 0.01)	285 (16.7)
> 2	29 (7.1)	79 (11.1)	64 (11.0)		172 (10.1)
Prior failure to stop violation					
0	377 (92.0)	707 (99.2)	575 (98.5)		1659 (97.2)
1	32 (7.8)	6 (0.8)	8 (1.4)	(p < 0.0001)	46 (2.7)
> 2	1 (0.2)	-	1 (0.2)		2 (0.1)
Prior distracted violation					
0	385 (93.9)	691 (96.9)	561 (96.1)		1637 (95.9)
1	25 (6.1)	17 (2.4)	21 (3.6)	(p < 0.01)	63 (3.7)
> 2	-	5 (0.7)	2 (0.3)		7 (0.4)
Prior other driving violation					
0	392 (95.6)	641 (89.9)	509 (87.2)	20.94	1542 (90.3)
1	16 (3.9)	57 (8.0)	57 (9.8)	(p < 0.01)	130 (7.6)
> 2	2 (0.5)	15 (2.1)	18 (3.1)		35 (2.1)
Total prior violations					
0	274 (66.8)	478 (67.0)	364 (62.3)	10.54	1116 (65.4)
1	91 (22.2)	124 (17.4)	124 (21.2)	(p < 0.05)	339 (19.9)
> 2	45 (11.0)	111 (15.6)	96 (16.4)		252 (14.8)
Prior collisions					
0	406 (99.0)	694 (97.3)	574 (98.3)	4.15	1674 (98.1)
1	4 (1.0)	19 (2.7)	10 (1.7)	(p = 0.13)	33 (1.9)
Events					
% Follow up violation	77 (18.8)	274 (38.4)	238 (40.8)	59.81	589 (34.5)

	($p < 0.0001$)

* Student t-tests were significant between education and the two fine groups ($p < 0.05$) but not significant between the fine and control; **2 individuals had postal codes in which Census Canada had no income information on and as such were deleted here.

3.5.2 Time to subsequent violations between groups

We wanted to test whether any statistically significant differences in regards to survival (i.e. time until first violation) existed between offenders who participated in the Option 4 workshop and those who received a fine. All offenders in the "Fine (Choice)" and "Fine (Mandatory)" groups who did not participate in an Option 4 workshop were categorized into a group called "fine/control" (n = 1,297) and compared to offenders who did complete an Option 4 workshop ($n = 410$). Utilizing Kaplan-Meier curves, Figure 3.1 visualizes the unadjusted Kaplan-Meier curves for each study group. Log Rank tests revealed differences time to subsequent violations ($p < 0.001$) between those who completed the Option 4 workshop and those who received a fine (Appendix c). Traffic offenders who received fines and did not complete an Option 4 workshop exhibited faster time to subsequent traffic violations compared to traffic offenders who completed the Option 4 workshop (Figure 3.1).

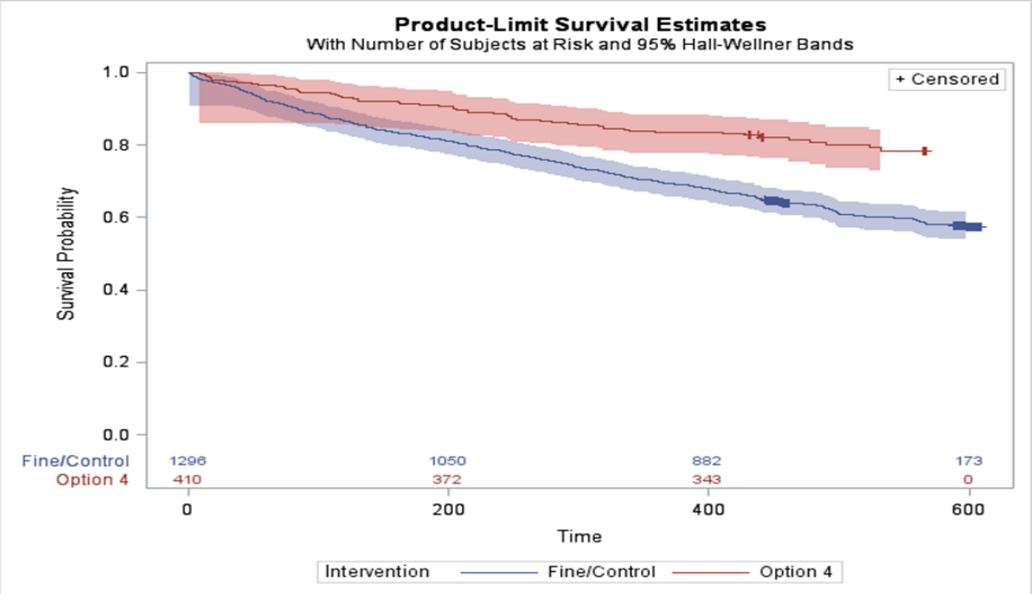

Figure 3.1. Unadjusted Kaplan Meir Survival Curves between the two interventions (Violations) with 95% confidence intervals indicated by shading.

Kaplan-Meir plots, stratified by sex and the various age groups, were used to test for differences in survival between those aforementioned groups (Figure 3.2). The Log Rank test revealed significant ($p < 0.05$) differences in traffic violation experiences among the various age groups but no differences ($p > 0.05$) between male and female offenders. That is, traffic offenders who were 19 years or younger were the fastest to commit a future violation compared to all other age groups, while offenders who were 50 or older were the slowest (Figure 3.2).

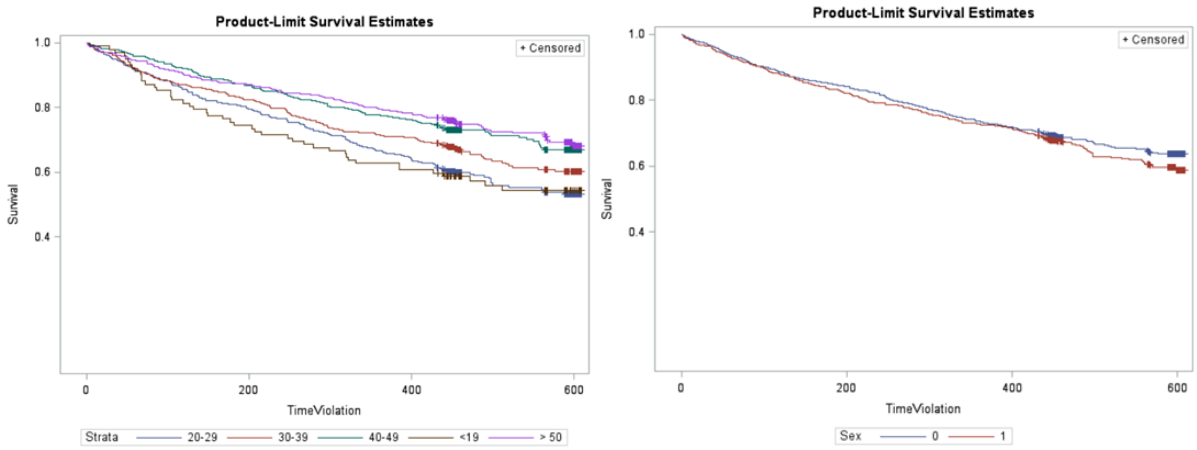

Figure 3.2. Unadjusted Kaplan Meir Survival Curves between Age groups and Sex (0 = Male, 1 = Female)

3.5.3 Results from Cox's Regression

Cox's regression was used to assess whether the risk of future violations was lower among offenders who completed Option 4 versus those who only received a fine. During the purposeful selection procedure, the variable detailing the geography of where the offender lived (Geography) was dropped due to non-significant p-values ($p < 0.05$) when conducting the Wald test (Bursac et al., 2008). The remaining predictors (age, campaign/season, intervention, median area income, prior collisions, prior violations, sex), were included in the final full model given the presence of confounders (> 15%) (Bursac et al., 2008). Tests for proportional hazards revealed that the final multivariate Cox's proportional model did not violate the PH assumption.

Unadjusted and adjusted hazard ratios along with their corresponding 95% confidence intervals are showcased in Table 3.2.

Table 3.2. Unadjusted and Adjusted Proportional Hazard Ratios (Violations) (N = 1,707) [a]

Demographics	Follow up violation (%) (n = 589)	No follow up violation (%) (n = 1118)	HR [a] (95% CI)	AHR [a] (95% CI)
Sex [b]				
Male	351 (59.6)	701 (62.7)	Reference	Reference
Female	238 (40.4)	417 (37.3)	1.10 (0.93,1.30)	1.24* (1.05, 1.47)
Median Area Income [c]				
$48,000 - $74,999	40 (6.8)	101 (9.0)	0.62* (0.44, 0.88)	0.75 (0.52, 1.06)
$75,000 - $99,999	119 (20.2)	263 (23.5)	0.66** (0.52, 0.85)	0.67** (0.52, 0.86)
$100,000 - $124,999	293 (49.7)	576 (51.5)	0.73** (0.60, 0.90)	0.75* (0.61, 0.92)
> 125,000	136 (23.1)	177 (15.8)	Reference	Reference
Age [b]	Mean = 37.1 SD = 13.89	Mean = 41.4 SD = 15.01	0.98*** (0.98,0.99)	0.99** (0.98, 0.99)
< 19	45 (7.6)	57 (5.1)	1.81** (1.29, 2.55)	1.68** (1.19, 2.37)
20 – 29	169 (28.7)	220 (19.7)	1.75*** (1.39, 2.20)	1.39* (1.10,1.77)
30 – 39	151 (25.6)	273 (24.4)	1.40* (1.11, 1.78)	1.30* (1.02, 1.66)
40 – 49	100 (17)	235 (21)	1.10 (0.84, 1.43)	0.97 (0.75, 1.27)
> 50	124 (21.1)	333 (29.8)	Reference	Reference
Geography				
Urban	583 (99)	1104 (98.7)	1.17 (0.52, 2.61)	-
Rural	6 (1)	14 (1.3)	Reference	Reference
Driving History (Last 2 Years)				
Prior Violations				
0	274 (46.5)	842 (75.3)	Reference	Reference
1	145 (24.6)	194 (17.4)	1.88*** (1.53, 2.29)	1.61*** (1.31, 1.98)
> 2	170 (28.9)	82 (7.3)	3.81*** (3.14, 4.62)	3.35*** (2.74, 4.09)

Prior Collisions				
0	573 (97.3)	1101 (98.5)	Reference	Reference
1	16 (2.7)	17 (1.5)	1.49 (0.90, 2.44)	0.76 (0.46, 1.26)
Treatment				
Campaign/Season				
First campaign	461 (78.3)	528 (47.2)	Reference	Reference
Second campaign	128 (21.7)	590 (52.8)	0.38*** (0.31, 0.46)	0.51*** (0.42, 0.63)
Intervention [b]				
Option 4	77 (13.1)	333 (29.8)	0.46*** (0.36, 0.58)	0.56*** (0.43, 0.71)
Fine/Control	512 (86.9)	785 (70.2)	Reference	Reference

***Notes*. a** three individuals were removed from the Cox's analysis due to two having missing values and one contributing 0 survival time; **b** Estimates from main effects model only; **c percentages do not add up to 100% due to missing values;** * $p < 0.05$; ** $p < 0.01$; *** $p < 0.0001$.

A bivariate model revealed that the rate of committing future violations after one and a half years was 54% lower among offenders who completed the Option 4 workshop (Hazard Ratio (HR) = 0.46, 95% CI: 0.36, 0.58) as compared to those who received a fine (Table 3.2). Additionally, offenders who had 2 or more traffic offences in the last two years (HR = 3.81, 95% CI: 3.14, 4.62) were most at risk for committing future violations compared to offenders with no violations (Table 3.2). At the univariate level, the rate of violation risk decreased by 2% for every unit increase in age (HR = 0.98) while those who participated in the second campaign (HR = 0.38, 95% CI: 0.31, 0.46) were 62% less likely to commit a future violation than those who participated in the first campaign (Table 3.2). However, neither sex, geography of residence, or prior history of collisions were statistically associated ($p > 0.05$) with future violations (Table 3.2).

After adjusting for confounders and important predictors, the final multivariate model revealed that offenders who completed the Option 4 workshop were 44% less likely to commit a future traffic offence than offenders who received a fine either voluntarily or involuntarily (AHR

= 0.56, 95% CI: 0.44, 0.72); Table 3.2). When comparing offenders who completed the Option 4 workshop with offenders who did not have an opportunity to choose whether to receive a fine or take the workshop (Fine – mandatory), the directionality (AHR = 0.58, 95% CI: 0.45, 0.76) and significance ($p < 0.0001$) remained relatively the same. Variables found statistically significant in the bivariate analysis retained their significance at the 0.05 level apart from Sex (Table 3.2). In the multivariate model, Female offenders were associated with a higher risk of future violations (AHR = 1.24, 95% CI: 1.05, 1.47) than their male counterparts (Table 3.2).

To better understand how Option 4 programming interacted with each of our predictors, interactions between Option 4 attendance and each of our predictors were tested. However, only two interaction terms (Intervention*Age, Intervention*Sex) were found to be statistically significant ($p > 0.05$) and incorporated in the final Cox's model. As such, the effect of the Option 4 programming is dependent on age as well as the sex of the Option 4 attendee. Table 3.3 summarizes the hazard ratios for each of our interactions.

Table 3.3. Cox's proportional model with interactions between Option 4 attendance and sex and age ($N = 1,707$)

Demographics[a]	Fine	Option 4
Sex		
Male	1.0 (Reference)	1.0 (Reference)
Female	1.37* (1.15, 1.64)	0.67 (0.42, 1.06)
Age		
Age (10 Year)	0.93* (0.87, 0.99)	0.71* (0.60, 0.83)

Notes. Notes. **a** three individuals were removed from the Cox's analysis due to two having missing values and one contributing 0 survival time; * $p < 0.05$

Among offenders who completed an Option 4 workshop, there are no significant gender differences (p = 0.09) in the risk of committing any subsequent traffic violation between female and male offenders (Table 3.3). However, there were gender differences among those who received a fine (Table 3.3). That is, the risk of committing a future violation was higher for

female offenders (AHR = 1.37, 95% CI: 1.15, 1.64) compared to male offenders (Table 3.3). Additionally, there were significant differences ($p < 0.05$) between offenders who completed an Option 4 workshop and those who received a fine. That is, the risk of committing any future violation was 63% (AHR = 0.37, 95% CI: 0.25, 0.55) lower for female offenders who completed Option 4 in comparison to female offenders who did not complete Option 4 and instead received a fine.

Regarding age, the effect of Option 4 in reducing the risk of violations is not significant for young offenders but is significant for older offenders (Table 3.3). That is, a 10-year increase in age for those who completed an Option 4 workshop is associated with a 29% (AHR = 0.71, 95% CI: 0.60, 0.83) reduction in risk of committing a traffic violation (Table 3.3). For example, among those who were 27 at the time they completed an Option 4 workshop, they reduced their future risk of traffic violations by 27% (AHR = 0.73, 95% CI: 0.55, 0.98) compared to someone who was 75 who reduced their risk by 80% (AHR = 0.2, 95% CI: 0.10, 0.42). Option 4 was not effective ($p > 0.05$) in reducing the risk of violations for young offenders who were between 16 and 26 at the time they completed the workshop. While there was also a reduction in the hazard (AHR = 0.93, 95% CI: 0.87, 0.99) of committing a future violation for every 10-year increase in age for those who received a fine, the reduction was far lower than those in the Option 4 group (7% vs. 27%, respectively); Table 3.3).

A final survivor function controlling for all predictors found in the final main effect and interactions Cox's model was visualized in Figure 3.3 and revealed that offenders who did not participate in Option 4 had a substantially shorter time to committing a future traffic violation than offenders who completed Option 4.

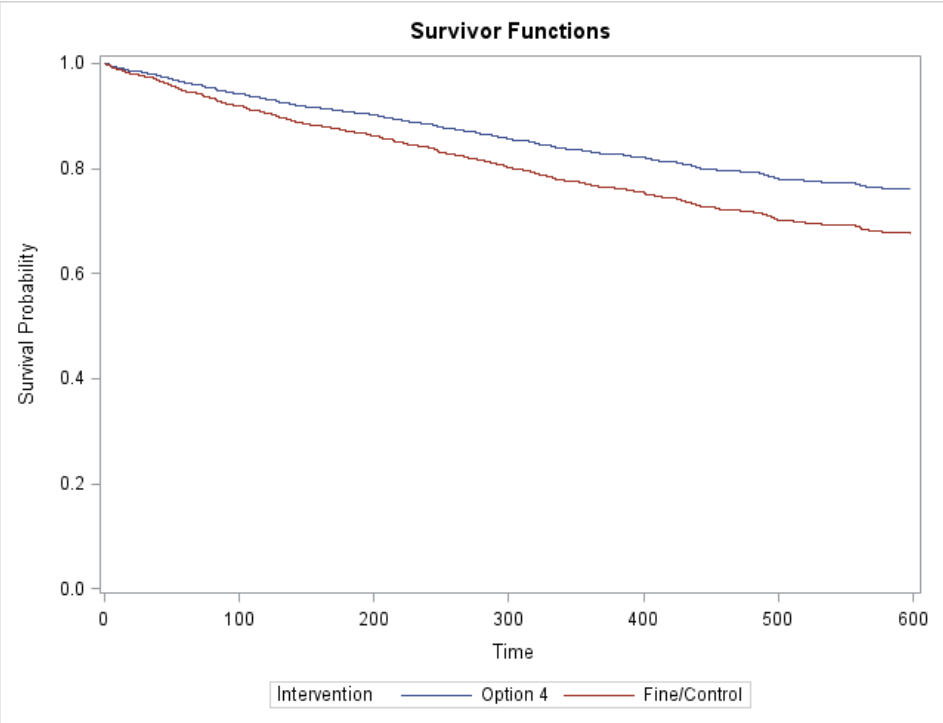

Figure 3.3. Adjusted survivor function utilizing the final main effects + interactions model

3.6 Discussion

Based on prior work, we hypothesized that participating in a DIP (Option 4), compared to only receiving a fine and not completing Option 4, would lead to a decreased risk in committing future traffic violations (Barrett, 2018; Harano & Peck, 1972; Kloeden & Hutchinson, 2006). Our results are consistent with our hypotheses that not only did survival vary between our various groups but that offenders who chose to participate in the Option 4 workshop had a lower risk for future violations prior to and after controlling for various environmental, socio-demographic, and driver history predictors. Additionally, female offenders as well as offenders who had a prior history of violations were the groups most at risk for committing a traffic violation one and a half years later following exposure to Option 4 programming or receiving a fine. Our findings corroborate much of the traffic safety literature that has evaluated DIPs compared with receiving a fine as well as risk factors for violations (Barrett, 2018; Harano & Peck 1972; Kloeden & Hutchinson, 2006; Wåhlberg, 2011; Zhang et al., 2013). However, unlike most of the literature,

our analyses showed that female offenders had a higher risk of committing future traffic violations than males (Zhang et al., 2013). These can be explained in two ways. First, our supplementary analysis compared offenders who completed Option 4 with offenders in the Fine-mandatory group only and revealed that sex was a non-significant ($p > 0.05$) predictor of follow up violations. Therefore, female offenders in the fine-choice group were offenders who were more likely to commit future violations as they were not motivated to learn about how they could modify their driving behaviours when offered the opportunity to do so. Secondly, prior research has found that female drivers are more likely to commit certain driving violations, such as cell-phone use while driving, than male drivers (Wilkinson, et al., 2015). As such, female offenders in our sample may have been more likely to commit specific future traffic offenses than men. However, our analysis did not test for specific violations. Nonetheless, our analyses confirmed that participation in the workshop exhibited a large reduction (44%) in violation risk as opposed to a small effect. Thus, the evidence suggests that incorporating Option 4 as part of law enforcement operations in Sherwood Park is an effective secondary intervention in reducing future traffic violations.

Furthermore, statistical interactions revealed that Option 4 programming were effective for older and female traffic offenders. Our current findings support prior research that found that older offenders who completed a driver improvement course had a lower probability of future violations than younger offenders (≤ 30) (Zhang et al., 2011). Greater effectiveness of Option 4 among older adults can potentially be explained by the Option 4 content and how it may be received by attendees as well as attitudinal differences between older and younger offenders. Older adults will generally respond more positively towards healthy behaviour messaging, such as exercise messaging, when said communication is presented as a gain-framed message,

promoting positive affect among viewers such as alertness and joy, rather than loss-framed messages, promoting negative affect such as fear or guilt (Liu et al., 2019; Notthoff & Carstensen, 2014). Given that the subject material in Option 4 was presented in an informative and interactive manner (i.e. gain-framed message) the older offenders in our sample (> 50) therefore may have responded more positively towards the messaging than younger offenders. Additionally, research has found that older drivers perceive traffic laws more importantly than younger drivers (Yagil, 1998). The combination of older offenders integrating Option 4 messaging more effectively than younger offenders as well as an already inherent greater sense of obedience to traffic laws than younger offenders could explain why Option 4 was so successful in reducing the violation risk among older offenders.

Regarding sex differences, we found some surprising findings. Contrary to prior research, which found that female drivers responded more to punishments and males more to reward, interactions in our final model demonstrated that female offenders were more likely to commit a future violation if they received a fine (punishment) than men (Castellà and Pérez, 2004). Instead, female offenders had a reduced risk of future unlawful driving if they completed an Option 4 workshop, compared to female offenders who only received a fine. A study focusing on traffic safety messaging found that not only are positively framed messages more effective in communicating and promoting safer driving behaviour but that drivers who are more involved in issues (i.e. more aware of the dangers of driving) will process the information better (Millar & Millar, 2000). Similar to older drivers, research has also found that female drivers are more likely to comply with traffic laws due to stronger perceptions of danger associated with traffic violations as well as a stronger sense of obligation to comply with laws than men (Yagil, 1998). This could be due to socialization processes experienced by the sexes in which females are

taught to be submissive, unlike males who are instructed to be independent (Yagil, 1998). Given that the Option 4 initiative educates all attendees on driving legislation as well as the risks associated with driving dangerously on roads, female offenders responded favourably to the workshop as it likely strengthened their awareness of traffic laws as well as heightened their perceptions regarding the dangers of committing violations which, then translated into better driving (Rawson, 2018).

Findings from the current study warrant additional critical reading. The use of the Campaign/Season was used to control for seasonality given that seasonality, particularly the fall season, is a potential risk factor for violations (Cheng et al., 2019). According to the multivariate model, offenders who were caught in the second campaign (fall season) had less risk of future violations. It should be noted however that their follow up time was drastically shorter than those who were in the first campaign. Stratifying the analysis by both campaigns revealed that the hazard ratios and their corresponding p values did not change in our final model. As a result, any interpretation regarding the campaign variable should be read with caution. Additionally, our first study confirmed socio- demographic and driver history differences between one group choosing to participate in Option 4 and the second group choosing to receive a fine. Kloeden & Hutchinson's (2006) evaluation precluded the authors from assigning any benefits regarding violation reduction solely to the educational workshop given that they also found pre-existing differences between offenders who chose the workshop and offenders who chose a fine. Likewise, our study also does not attribute the reduction in violations exclusively to Option 4 as it is likely that the unique characteristics that the offenders had prior to exposure, and their motivation to learn about traffic safety, might have impacted their risk of violations one and a half years later.

3.7 Study Limitations

Various limitations are present in the current study. Our study failed to control for variables that have routinely been utilized in similar evaluations such as levels of speed and years that offenders were licensed for due to data unavailability which could have potentially changed our findings (Barrett, 2018; Li et al., 2011).

Additional limitations present in the current study may have also contributed to information and selection bias. Since our study relied on reported records of traffic violations rather than directly observing offenders for one year, our current study did not consider unreported violations which similarly plagued other traffic safety studies that used policing databases or self-reports of traffic violations (Elias, 2018; Lawpoolsri et al., 2007; Li et al., 2011; Wåhlberg, 2010). Thus, the percentage of individuals committing a subsequent violation is likely underestimated in this study given that most violations, particularly speeding, are not recorded by law enforcement personnel (Li et al., 2011). There is a risk that offenders may have driven to other provinces and/or countries and could have committed a violation. Data pertaining to these types of events would not be collected by the databases (the Enforcement Services Records Management System; JOIN; PROS; ROADS) and thus not incorporated in the analysis while no scholarly work has been conducted to validate these databases. The current study is also prone to selection bias as individuals stopped during the campaign dates could select whether they would receive a fine or take the educational workshop which, increased the likelihood of self-selection bias (Kloeden & Hutchinson, 2006).

Despite the limitations, all databases contain the most up to date and complete traffic information for all licensed Albertan traffic offenders. Additionally, the PROS, JOIN, and ROADS databases are routinely used by police departments in the province to assess for

violation and collision history. To minimize data entry errors, a second-team member randomly checked 10% of entered records to ensure data entry was accurate and contained no data entry errors.

3.8 Conclusion

The current study is the first prospective cohort study to directly compare time to subsequent traffic violations between offenders who received an educational workshop or a fine in a Canadian sample of offenders. Our study was also the first Canadian study to investigate the interaction between DIPs and demographics of interest (age and sex). Findings from our study identified groups (i.e. younger and female offenders, as well as those with a history of violations) in Alberta who may be at a higher risk for future violations as well as provided evidence that Option 4 is an effective strategy in reducing the risk of future violations among Albertan offenders. Albertan agencies tasked with making Albertan roads safer should not only continue implementing and expanding Option 4 across the province, but also tailor their efforts on increasing participation among groups whom the workshop may have the most benefit for (i.e. female and offenders older than 27). Given that Albertan female offenders already have a greater risk of future violations than their male counterparts, emphasis on enhancing female participation of Option 4 is important for Sherwood park and other Albertan Law enforcement personnel.

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Chapter 4: Does participation in a driver education program reduce risk of subsequent traffic collisions?

4.1 Introduction

Eradicating injuries and fatalities associated with traffic collisions around the world has become a major focus in the injury prevention field. Numerous engineering strategies, such as making vehicles and roads safer for users, have been associated with a reduction in traffic injuries and deaths (World Health Organization, 2018). Yet, an estimated 94% of all collisions are due to driver errors including performance and decision errors such as driving too fast or illegal maneuvers (Singh, 2015). As such, reducing driver errors by deterring offenders from committing violations with the threat of imposing monetary fines or teaching offenders how to drive safely with the use of educational programming (i.e., driver improvement programs) continue to be the most popular interventions in preventing traffic collisions (Davey & Freeman, 2011; Struckman-Johnson et al., 1989; Wåhlberg, 2010, 2011, 2013).

Yet, despite the widespread practice of administering fines to traffic offenders or having offenders complete a driver improvement program (DIP), the literature has failed to provide definitive evidence that either strategy is effective in decreasing the risk of future collisions. Some studies have shown fines to be an effective measure in reducing the risk of future collisions while others found them ineffective (Li et al, 2011; Luca, 2015; Redelmeier et al., 2003; Wagenaar et al., 2007). Unlike fines, most of the literature seems to suggest that DIPS have no impact or effect on reducing collision rates. A general commentary and conclusion of over 15 reviews and studies over the decades by Wåhlberg (2018) concluded that DIPs do not have any effect on reducing motor vehicle accidents or that the effects are small as to have no meaningful significance. A Cochrane review also echoed this sentiment by finding that post-

licence driver education programs have small or non-significant reduction on collision rates (Ker et al., 2003).

Research comparing groups of traffic offenders who completed a DIP with groups who only received a fine have also been inconclusive regarding which intervention is superior in reducing future crashes. English and Australian evaluations found that while those who completed a DIP committed less future traffic violations than those who simply received a fine, there was no evidence that DIPs reduced future collisions (Barrett, 2018; Kloeden & Hutchison, 2006). Harano and Peck (1972) utilized an experimental design, comparing traffic offenders who attended group meetings as part of an educational curriculum and a control group that did not. The study found that the group who completed the driving curriculum, particularly those with no prior involvement in crashes, had a lower future accident risk than those who simply paid their fines (Harano & Peck, 1972). Another study that compared a group of drivers who completed an educational workshop with a group that did not found that the workshop did not reduce the risk of future violations but was effective in reducing collision risks (Villaveces et al., 2011). Such contradictory findings make it difficult for law enforcement personnel and traffic safety professionals to effectively draw conclusions as to which strategies to implement when attempting to reduce collisions within their jurisdictions.

Some of the methodological limitations that were present in the aforementioned evaluations have include low sample sizes and infrequent events (i.e. collisions) as well as a lack of control groups (i.e., those who haven't had choices to receive a fine or education) (Barrett, 2018; Kloeden & Hutchison, 2006). Prior studies also have not compared groups of offenders who willingly chose to receive a fine or DIP with offenders who were mandated to receive a fine.

Lastly, no work has been conducted in Alberta to evaluate whether an Albertan based DIP (i.e. Option 4) is effective in reducing the risk of future collisions.

Our study addressed the prior mentioned limitations as well as contributed to the literature in numerous ways. First, our study was the first to test whether participating in a workshop designed to enhance knowledge on traffic safety, as opposed to receiving a traffic fine (i.e. Option 4), reduces the risk of subsequent collisions among a sample of Canadian offenders. Additionally, this study was also the first to evaluate whether Option 4 was effective in reducing the risk of future collisions. Lastly, this study was the first to explore whether offenders who chose to receive a fine, as opposed to learning more about traffic safety, are a different group of offenders compared to others that weren't given that same option.

Thus, our study objectives were to determine whether the incidence of subsequent collisions was lower in the education group than in the fine group before and after controlling for potential confounders. Based on prior evaluative work, we hypothesized that offenders who participated and completed the Option 4 workshop were slower to experience and had less risk of being involved in a collision one and a half years later than offenders who received a fine and were not exposed to Option 4 programming (Harano & Peck, 1972; Villaveces et al., 2011).

4.2 Context for the Present Study

Option 4 is a 90-minute DIP that has been implemented in Alberta since 1988 (Narbonne, 2017). The name “Option 4” originates from the three options that are displayed on the back of a violation notice that drivers receive when they are caught committing a traffic violation in Alberta which are paying a fine (Option 1), pleading not guilty by mail (Option 2) or in court (Option 3) (Alberta Occupant Restraint Program, 2019). Initially, Option 4 was designed to teach drivers on how to handle and maintain care of child restraints, such as booster seats, child safety

seats, etc., as opposed to drivers simply paying a traffic fine (Alberta Occupant Restraint Program, 2019). The Option 4 framework has since expanded to incorporate drivers who were caught committing traffic violations other than misuse of child restraints such as speeding, failing to stop at a stop sign, among many others (Rawson & Narbonne, 2018). Similar to child restraints, the Option 4 program is used to educate drivers and other vehicle occupants on traffic safety offences (Rawson & Narbonne, 2018). Content for each session not only educates offenders about the legislation surrounding a violation (i.e. speeding or failure to stop at a stop sign) and the Vision Zero philosophy but also about the risks of these violations (Rawson, 2018). Each session is also interactive as it asks attendees how law enforcement personnel can improve traffic safety measures and help officers identify gaps in driver education (Rawson, 2018). Over the years, Option 4 workshops have generally been implemented during various Albertan law enforcement traffic campaigns.

In 2017, Strathcona County's Royal Canadian Mounted Police (RCMP) and Enforcement Services launched two law enforcement campaigns. The first campaign, *Neighbourhood Traffic Safety*, was conducted between May 14th and 22nd, 2017 and focused on addressing residential speeding in and around Sherwood Park (Rawson, 2017). The goal of the campaign and the focus of the Option 4 workshops during this campaign were to heighten awareness among attendees on the risks speeding poses to pedestrians (Rawson, 2017). A second campaign, *Stop Sign Safety Campaign*, was also held in Sherwood Park in the fall of 2017 (October 8th and October 14th, 2017) (Rawson, 2018). Unlike the first campaign, the second campaign focused on increasing stop sign compliance rather than residential speeding (Rawson, 2018). The campaign and Option 4 workshops focused on heightening awareness regarding stop sign compliance and how offenders should maneuver around stop-controlled intersections (Rawson, 2018). The formats of

the workshops were essentially the same with the only difference being the focus of the campaign changing from residential speeding to stop sign compliance (Rawson, 2018). During both campaigns, offenders who were caught committing any traffic violation were offered the choice of either paying their fine or attending the Option 4 program (Rawson, 2017).

4.3 Methods

4.3.1 Study population and design

The study population used for this analysis were Albertan traffic offenders who were pulled over by Peace Officers as well as the Royal Canadian Mounted Police (RCMP), due to committing any traffic violations, during the *Neighbourhood Traffic Safety* and the *Stop Sign Safety* Enforcement Campaigns in Sherwood Park, Alberta in 2017. The *Neighbourhood Traffic Safety* campaign was conducted between May 14th and 22nd, while the Stop Sign Safety campaign was conducted between October 8th to October 14th (Rawson, 2017; 2018). The *Neighbourhood Traffic Safety* campaign focused on addressing residential speeding while the *Stop Sign Safety* campaign focused on increasing stop sign compliance in and around Sherwood Park (Rawson, 2017; 2018). During each campaign, all traffic offenders were asked if they were interested in participating in the Option 4 workshop as opposed to receiving a fine. Offenders interested in attending the Option 4 workshop were instructed that upon completion of a workshop, their traffic offence would be reduced to a warning and would not have to pay a fine. These offenders were categorized into an 'Option 4' group. Traffic offenders who chose not to participate in an Option 4 workshop and to receive a fine instead were classified into a "Fine (choice)" group. The study also established a third comparison group of traffic offenders who committed any traffic violation outside of the first (May 1st to May 13th) and second (September 25th to October 7th) campaign dates (Rawson, 2017; 2018). These traffic offenders received a

mandatory fine and were not provided the opportunity to participate in an Option 4 workshop and served as a control group for the study, i.e., they were categorized into a "Fine (mandatory)" group. Non-Albertan offenders, defined as those who both did not have Albertan License plate numbers and Postal Code residences, were excluded from the study.

4.3.2 Data Sources

Data used for this study were contained and linked across several administrative databases, including the Enforcement Services Records Management System, Justice Online Information Network (JOIN), and the Police Reporting and Occurrence System (PROS) databases as well as the 2016 Canadian census. All data were accessed, except for the 2016 Canadian census, from the Enforcement Services located in Sherwood Park, Alberta.

Data describing demographic characteristics of all offenders were collected from the Enforcement Services Records Management System. The Enforcement Services Records Management System is an in-house data warehouse environment that contains electronic records of offenders who were pulled over by the Sherwood Park enforcement services due to committing a traffic violation in Sherwood Park and surrounding areas. Given that everybody in the database committed a traffic offence, this database was utilized to identify the offenders who were stopped during the two campaigns.

The Justice Online Information Network (JOIN) is an Albertan provincial court online information database which collects and stores information pertaining to court appearances criminal convictions, fines, and offender status (Legislative Assembly of Alberta, 2011; Edmonton Police Service, 2019). Police services across Alberta utilize JOIN to perform police record checks as this system records a person's interaction with the legal system (Edmonton Police Service, 2019). The JOIN database was utilized to collect data on the number of traffic

violations two years prior to being stopped during one of the campaigns as well as type of traffic violation.

Data pertaining to traffic collisions were collected from the Police Reporting and Occurrence System (PROS). The Police Reporting and Occurrence System (PROS) is an RCMP operated data warehouse that records and manages information pertaining to police occurrences, such as traffic collisions, in Canada (Termium Plus, 2009; Royal Canadian Mounted Police, 2005). As such, PROS was used in order to extract data on a offender's collision history in the past two years as well as to determine whether a offender committed a collision within one and a half years after receiving a fine or participating in the Option 4 workshop.

Lastly, we extracted the median household income by postal codes (first three digits) by merging our final dataset with the 2016 Canadian Census. Data pertaining to the 2016 Canadian Census was extracted from the University of Alberta library database.

4.3.3 Ethics

Ethics to collect administrative data from the Strathcona county Enforcement services and to conduct this project was approved by the University of Alberta (study ID: Pro00088817).

4.3.4 Data Extraction Strategy and Quality Assurance

Once ethics was approved initially, a trained analyst with the Enforcement services, who had extensive experience working with these databases, created two datasets stored in an excel format. The first data set contained every offender (92,322) who was pulled over by enforcement services in 2017 in Sherwood Park (Appendix A). This dataset contained individuals who chose to receive a fine and those who completed the Option 4 workshop. The option to participate in Option 4 was only provided to offenders who were stopped during the two campaigns dates. The

second dataset only contained offenders who both participated and completed the Option 4 workshop (Appendix A).

Next, a new dataset was created, from dataset 1, that filtered for offenders who committed a violation in the months during the first (May 1st, 2017 to May 22nd, 2017) or second campaign (September 25th, 2017 to October 14th, 2017) (Appendix A). This new dataset was then merged with data set 2 using a citation number ID which is a unique ID given to an offender who committed a violation (Appendix A). Prior to merging the two datasets, the Option 4 spreadsheet contained a column ("Intervention") that had all cells filled in with the term "Option 4". In the merged data set, blank cells in the intervention column would signify which fine group (choice or mandatory) each offender belong to based on the date that they were stopped. That is, offenders who committed any violation between May 1st to May 13th or September 25th to October 7th were classified in the "fine(mandatory)" group while, offenders who committed any violation between May 14th to 22nd or October 8th to October 14th were categorized in the "fine(choice)" group. Offenders that had the "Option 4" term where those who participated and completed Option 4. From this dataset, there were 260 rows that had duplicate rows or other erroneous values and as such were deleted (Appendix A). After duplicates were removed, 1,736 unique offenders were left in the dataset (Appendix A). Enforcement services would enter the pertinent information using the Enforcement Services Records Management System, JOIN, and PROS databases. Once all data had been entered, the enforcement services team would then send that data to us. After we received the data, 29 offenders had non-Albertan postal codes and as such were deleted bringing our total sample size down to 1,707 (Appendix A). To collect our median household income and residence data we merged the 2016 Canadian census with the final data set using the first three digits of offender's postal code (Appendix A). Offenders that

had a zero as a second digit in their postal code would be classified as living in rural areas while the remaining offenders would be classified as urban.

To minimize data entry errors, prior to being sent data back to us a second team member manually checked 10% of randomly chosen records to ensure data entry was accurate. Once data was confirmed to be accurate the data was sent back to us. After all data had been collected, we did a final check to ensure that there were no duplicate rows and that the information that was accurate.

4.3.5 Variables

Dependent Variables

The outcome variable was a dichotomous variable regarding whether someone was involved in a collision (0= No, 1= Yes) after either receiving a traffic fine or completing the option 4 workshop prior to the follow-up date (December 31st, 2018).

Time variable

For offenders who received a fine, both in the "fine(choice)" and "fine(mandatory)" groups, their time in the study was defined as the days from the date they received a fine until their first collision. Regarding offenders who completed the educational workshop ("Option 4"), their time was defined as the date they completed the workshop until the date that they had an event (i.e. collision) occur. All offenders who did not have an event occur were censored after the follow up date (December 31st, 2018).

Predictors

Predictors were classified into four categories; demographics (sex, age), community (income, residence), past two-year driver history (violations, collisions) and variables pertaining to the interventions (campaign, intervention). Demographic predictors as well as predictors

related to driving and community were selected based on prior evaluations and studies that have been conducted within and outside of Alberta (Anowar et al., 2013; Factor et al., 2008; Kim et al., 2012; Kmet et al., 2003; Siskind et al., 2011; Valent, et al., 2002; Villaveces et al., 2011; Yasmin et al., 2012; Zhang et al., 2013). For a list of how variables were coded please see Appendix B.

Predictor variables were coded at the time that the traffic offender was pulled over during one of the campaign months including age, sex, area median income, and geography of residence. Prior driving history was assessed within two years from the index date that the offender was stopped during one of the campaigns (Li et al., 2011; Oviedo-Trespalacios et al., 2017; Villaveces et al., 2011). Area median income was assessed by matching the postal code of individuals who were ticketed with the 2016 Canadian Census for that postal code area (Li et al., 2011).

Various environmental variables were considered including the day, month, and season of offenders when they were pulled over. Given that not all environmental variables could be incorporated, due to overfitting the model, a variable was created (Campaign/Season) which categorized offenders in either the first (0) or second campaign (1) and included in the model selection procedure. The variable served a twofold purpose. First, the variable would control for the potential bias and effect of combining the data from the two campaigns, given that offenders from the first campaign contributed a substantially larger survival time than those in the second campaign (c.f. Edwards et al., 2020). Secondly, the variable would control for seasonality given that the first campaign was in the spring while the second was in the fall.

4.4 Data Analysis

4.4.1 Statistical analysis

The Statistical Analysis System (SAS) software (Version 9.4) was used for all statistical analyses while R was used to test for Schoenfeld residuals using the "survival" package (SAS Institute Inc, 2016; Therneau, 2015). The statistical significance cut-off was established at $p < 0.05$. Various studies and other evaluations were referenced for guidance when conducting our analyses (Jones 1997a, 1997b; Lawpoolsri et al., 2007; Li et al., 2011; Raub et al., 1999; Roman et al., 2013; Zhang et al., 2011).

4.4.2 Procedures

Descriptive statistics assessed the percentage of offenders who experienced a collision during the one and a half year follow up period. First, we calculated frequencies and percentages of offenders in our fine and education groups by our predictor variables of interest. We also conducted Chi-Square and Fisher's exact tests for our categorical variables to test for bivariate associations between our predictors and offenders who completed the Option 4 workshop and offenders who received the fine. For variables that violated one or more Chi-square test assumptions (i.e. expected values less than 5, etc) Fisher's Exact tests were conducted.

Survival analyses were then conducted in order to assess differences in time to subsequent collisions between Option 4 participants and fine group before and after controlling for potential confounders. Kaplan-Meier curves were used to visualize the effects of education and fine group on this outcome as well as among the various age groups and sex of the offender (i.e. collision risk) (Li et al., 2011). In order to statistically test whether survival varied between the two groups, log-rank tests were employed. The treatment variable was converted from a trichotomous to a binary variable by collapsing the two fine groups ("Fine-Choice" and "Fine-

Mandatory") into one group (Fine/control) to better facilitate analysis. Prior to model building, collinearity was assessed using Variance Inflation Factor (VIF) and revealed that collinearity existed when incorporating "total prior violations" and the individual violation variables (i.e. prior speeding, failure to stop violation, distracted driving, and other violations). As such, only the "total prior violations" was incorporated which categorized whether offenders had no violations (0), one violation (1), two or more violations (>2) two years prior to being stopped (Li et al., 2011; Villaveces et al., 2011). Keeping this variable and eliminating the other driving variables avoided collinearity and overfitting the final multivariate Cox's model. During the model selection procedure, age was transformed into a categorical variable (i.e. < 19, 20 – 29, 30 – 39, 40 – 49, > 50) for the final multivariate Cox's model as it violated the linear assumption.

After modeling time to subsequent collisions between groups, bivariate and multivariate Cox's proportional hazards models were fitted. We utilized a purposeful selection methodology to create a parsimonious multivariate Cox's proportional hazard model to address our objective (Bursac et al., 2008). Interactions found to be significant, using the Wald test, were incorporated in the final Multivariate Cox's proportional model (Bursac et al., 2008). Hazard ratios and their corresponding 95% confidence intervals were computed using the profile likelihood method given its greater accuracy than the Wald Method (Allision, 2010).

After the final multivariate Cox's proportional models were built, the proportional hazards (PH) assumption for the final main effect and interaction multivariate models, as well as each predictor variable was assessed via three methods. We first assessed proportionality using the Schoenfeld residual global test (Therneau, 2015). Non-significant global test and individual p values ($p > 0.05$) would indicate that the proportional hazards assumption was met given a lack of statistical interaction with time (Therneau, 2015). Secondly, martingale residuals were

conducted to test for non-proportionality using methods originally explored by Lin et al. (1993) (Allison, 2010). Similar to the Schoenfeld residuals, non-statistical p values for each variable would indicate that the PH assumption has been met (Allison, 2010). Lastly, to assess whether each variable included in our study met the proportional hazards assumption, each predictor and their categories were first plotted on a log minus log (LML) plot to assess interaction with time. Visual inspections of each plot would indicate non-proportionality. However, in order to statistically test whether non-proportionality was met, each variable would be assessed with time as the outcome (Allison, 2010). Non-significant p values ($p > 0.05$) would indicate that the PH assumption had been met (Allison, 2010). Once all three methods yielded non - significant p values, we would confirm that the PH assumption has not been violated and we could proceed with reporting the results.

4.5 Results

4.5.1 Demographic and descriptive results

In total, 1,707 Albertan offenders, who were stopped during the two enforcement campaigns, were included in this study (Table 4.1). Of those 1,707 offenders, 410 offenders completed an Option 4 workshop in lieu of paying their traffic fine, while 713 offenders opted to receive a fine instead of participating in an Option 4 workshop (Table 4.1). An additional 584 offenders were also selected to serve as a control group as they were not given the opportunity to participate in Option 4 (Table 4.1). The demographics of offenders as well as the Chi-Square and Fisher exact tests between our three groups and predictors are described in Table 4.1. Most (62%) offenders who were stopped during the campaigns were male whereas just over a quarter of offenders (27%) were fifty years or older (Mean = 39.9, Median = 38, SD= 14.77. Range= 16 - 91); Table 4.1). Over half of participants (51%) lived in communities where the Median

household income was between $100,000 and $125,000 and only 1% lived in rural communities (Table 4.1). The vast majority of offenders did not commit a speeding (73%), failure to stop (97%), distracted (96%) or other (90%) driving violation two years before being stopped in one of the campaigns while only 2% of offenders had a collision within two years of being stopped during one of the campaigns (Table 4.1). Chi-square and Fisher exact tests confirmed statistically significant demographic differences such as age and area income ($p < 0.05$) as well as prior history of all violations between offenders of all groups (Table 4.1). 5% of offenders had a follow-up collision after receiving a fine or completing the Option 4 workshop (Table 4.1). However, the number of collisions among all three groups (education, fine-choice and mandatory) was similar and non-statistically different ($p > 0.05$); Table 4.1).

Table 4.1. Baseline Demographic Characteristics (Study 3)

Demographics	**Education (*n* = 410)**	**Fine (Choice) (*n* = 713)**	**Fine (Mandatory) (*n* = 584)**	$\chi 2$ (P value)	Total (*N* = 1,707)
Sex					
Male	238 (58)	448 (62.8)	366 (62.7)	2.93	1052 (61.6)
Female	172 (42)	265 (37.2)	218 (37.3)	(p = 0.23)	655 (38.4)
Age*	Mean = 42.8 SD = 16.03	Mean = 38.9 SD = 14.11	Mean = 39.2 SD = 14.39		
< 19	32 (7.8)	38 (5.3)	32 (5.5)		102 (6.0)
20 – 29	61 (14.9)	181 (25.4)	147 (25.2)		389 (22.8)
30 – 39	101 (24.6)	180 (25.2)	143 (24.5)	24.64	424 (24.8)
40 – 49	83 (20.2)	139 (19.5)	113 (19.3)	(p < 0.01)	335 (19.6)
> 50	133 (32.4)	175 (24.5)	149 (25.5)		457 (26.8)
Area median Income**					
$48,000 - $74,999	31 (7.6)	60 (8.4)	50 (8.6)		141 (8.3)
$75,000 - $99,999	62 (15.1)	173 (24.3)	147 (25.2)	42.69	382 (22.4)
$100,000 - $124,999	265 (64.6)	332 (46.6)	272 (46.6)	(p < 0.0001)	869 (50.9)
> $125,000	52 (12.7)	147 (20.6)	114 (19.5)		213 (18.3)
Residence					
Rural	1 (0.2)	10 (1.4)	9 (1.5)	(p = 0.10)	20 (1.2)
Urban	409 (99.8)	703 (98.6)	575 (98.5)		1687 (98.8)
Campaign/ Seasons					
Campaign 1	156 (38)	401 (56.2)	432 (74)	129.01 (p < 0.0001)	989 (57.9)
Campaign 2	254 (62)	312 (43.8)	152 (26)		718 (42.1)
Driving History (Last 2 Years)					

Prior speeding violation					
0	326 (79.5)	522 (73.2)	402 (68.8)	15.95 (p < 0.01)	1250 (73.2)
1	55 (13.4)	112 (15.7)	118 (20.2)		285 (16.7)
> 2	29 (7.1)	79 (11.1)	64 (11.0)		172 (10.1)
Prior failure to stop violation					
0	377 (92.0)	707 (99.2)	575 (98.5)	(p < 0.001)	1659 (97.2)
1	32 (7.8)	6 (0.8)	8 (1.4)		46 (2.7)
> 2	1 (0.2)	-	1 (0.2)		2 (0.1)
Prior distracted violation					
0	385 (93.9)	691 (96.9)	561 (96.1)	(p < 0.01)	1637 (95.9)
1	25 (6.1)	17 (2.4)	21 (3.6)		63 (3.7)
> 2	-	5 (0.7)	2 (0.3)		7 (0.4)
Prior other driving violation					
0	392 (95.6)	641 (89.9)	509 (87.2)	20.94 (p < 0.01)	1542 (90.3)
1	16 (3.9)	57 (8.0)	57 (9.8)		130 (7.6)
> 2	2 (0.5)	15 (2.1)	18 (3.1)		35 (2.1)
Total prior violations					
0	274 (66.8)	478 (67.0)	364 (62.3)	10.54 (p < 0.05)	1116 (65.4)
1	91 (22.2)	124 (17.4)	124 (21.2)		339 (19.9)
> 2	45 (11.0)	111 (15.6)	96 (16.4)		252 (14.8)
Prior collisions					
0	406 (99.0)	694 (97.3)	574 (98.3)	4.15 (p = 0.13)	1674 (98.1)
1	4 (1.0)	19 (2.7)	10 (1.7)		33 (1.9)
Events					
% Follow up collision	15 (3.7)	40 (5.6)	23 (3.9)	3.08 (p = 0.21)	78 (4.6)

* Student t-tests were significant between education and the two fine groups ($p < 0.05$) but not significant between the fine and control; **2 individuals had postal codes in which Census Canada had no income information on and as such were deleted here.

4.5.2 Time to subsequent collisions between groups

We wanted to test whether any statistically significant differences in regards to time until the occurrence of a collision existed between offenders who participated in the Option 4 workshop and those who received a fine. All offenders in the "Fine (Choice)" and "Fine (Mandatory)" groups who did not participate in an Option 4 workshop were categorized into a group called "fine/control" (n = 1,297) and compared to offenders who did complete an Option 4 workshop (n = 410). Utilizing Kaplan-Meier curves, Figure 4.1 visualizes the unadjusted Kaplan-Meir curves from each study group. Log Rank tests revealed no statistically significant

differences regarding time to subsequent collisions ($p > 0.05$) between those who completed the Option 4 workshop and those who received a fine (Appendix c). That is, traffic offenders who completed an Option 4 workshop exhibited similar times to subsequent traffic collisions compared to offenders who received a fine (Figure 4.1).

Kaplan-Meir plots, stratified by sex and the various age groups, were used to test for differences in time to collision between those groups (Figures 4.2). The Log Rank test revealed significant ($p < 0.05$) differences among the varying age groups but no differences ($p > 0.05$) between male and female offenders (Appendix c). Specifically, traffic offenders who were 19 years or younger were the fastest to experience a collision compared to all other age groups while offenders who were 50 or older were the slowest (Figure 4.2).

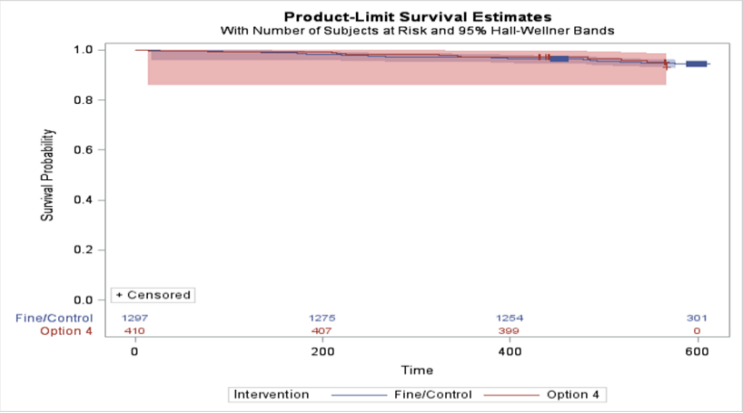

Figure 4.1: Unadjusted Kaplan Meir Survival Curves between the two interventions (Collisions) with 95% confidence intervals indicated by shading

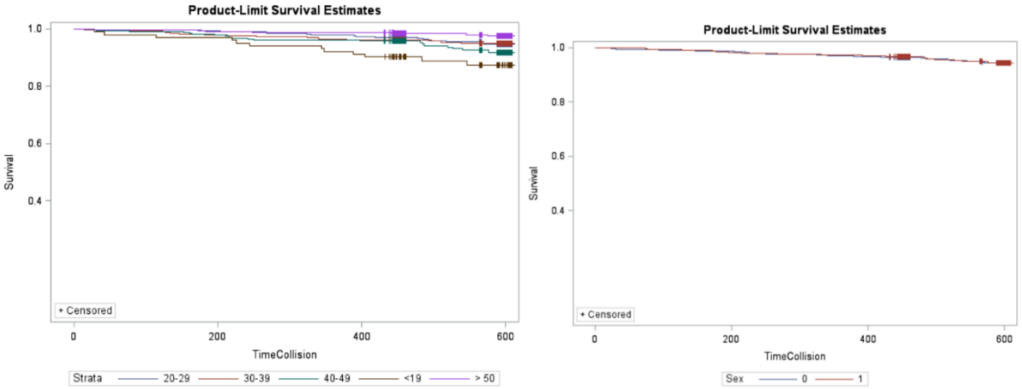

Figure 4.2: Unadjusted Kaplan Meir Survival Curves between Age groups and sex (0 = Male, 1 = Female) (Collisions).

4.5.3 Results from Cox's regression results

Secondly, we were interested in assessing whether the risk of future collisions was lower among offenders who completed Option 4 versus those who only received a fine. During the purposeful model selection, no confounders were present (< 15%) (Bursac et al., 2008). As such, the final reduced model was selected which, only included variables that were found statistically significant ($p < 0.05$) using the Wald test (Bursac et al., 2008). Given that sex and the group variables were found non-statistically significant, their adjusted hazard ratios were not reported. The PH assumption was met with the final reduced model. Unadjusted and adjusted hazard ratios along with their corresponding 95% confidence intervals, in the reduced model are showcased in Table 4.2.

Table 4.2. Unadjusted and Adjusted Proportional Hazard Ratios (Collisions) (n = 1,707) [a]

Demographics	Follow up collision (%) (n = 78)	No follow up collision (%) (n = 1629)	HR (95% CI)	AHR (95% CI)
Sex				
Male	48 (61.5)	1004 (61.6)	Reference	Reference
Female	30 (38.5)	625 (38.4)	1.00 (0.63, 1.57)	-
Income				
$48,000 - $74,999	4 (5.1)	137 (8.4)	0.40 (0.14, 1.17)	0.48 (0.16, 1.41)
$75,000 - $99,999	10 (12.8)	372 (22.8)	0.36* (0.17, 0.77)	0.28** (0.12, 0.65)
$100,000 - $124,999	41 (52.6)	828 (50.8)	0.65 (0.39, 1.09)	0.58* (0.32, 0.98)
> $125,000	22 (28.2)	291 (17.9)	Reference	Reference
Age				
< 19	12 (15.4)	90 (5.5)	5.98*** (2.52, 14.20)	5.39** (2.24, 12.97)
20 – 29	17 (21.8)	371 (22.8)	2.16 (0.96, 4.84)	1.99 (0.88, 4.50)
30 – 39	19 (24.4)	405 (24.9)	2.34* (1.06, 5.16)	2.28* (1.01, 5.13)
40 – 49	21 (26.9)	315 (19.3)	3.26** (1.49, 7.12)	3.09** (1.41, 6.78)
> 50	9 (11.5)	448 (27.5)	Reference	Reference
Geography				
Urban	75 (96.2)	1612 (99)	0.26* (0.08, 0.81)	0.10** (0.03, 0.40)
Rural	3 (3.8)	17 (1)	Reference	Reference

Driving History (Last 2 Years)				
Prior Violations				
0	37 (47.4)	1079 (66.2)	Reference	Reference
1	17 (21.8)	322 (19.8)	1.36 (0.76, 2.42)	0.96 (0.54, 1.72)
> 2	24 (30.8)	228 (14)	2.68** (1.60, 4.49)	1.98* (1.16, 3.38)
Prior Collisions				
0	73 (93.6)	1601 (98.3)	Reference	Reference
1	5 (6.4)	28 (1.7)	3.24* (1.31, 8.02)	1.64 (0.64, 4.16)
Treatment				
Campaign/Season				
First Campaign	69 (88.5)	920 (56.5)	Reference	Reference
Second Campaign	9 (11.5)	709 (43.5)	0.25** (0.12, 0.51)	0.28** (0.13, 0.58)
Group				
Education	15 (19.2)	395 (24.2)	0.89 (0.51, 1.58)	-
Fine/Control	63 (80.8)	1234 (75.8)	Reference	-

***Notes*. a** two individuals were removed due to two having missing values; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.0001$.

A univariate model revealed that the rate of experiencing future collisions among those who completed an Option 4 workshop was lower (Hazard Ratio (HR) = 0.89, 95% CI: 0.51, 1.58) than those who received a fine however this relationship was not significant ($p > 0.05$) while participating in the second campaign (HR = 0.25, 95% CI: 0.12, 0.51), were protective against future collisions (Table 4.2). Albertan offenders who were in their thirties (HR = 2.34 , 95% CI: 1.06, 5.16), forties (HR = 3.26, 95% CI: 1.49, 7.12), and younger than 19 (HR = 5.98, 95% CI: 2.52, 14.20) at the time of being stopped during one of the campaigns, were more likely to be involved in a collision at some point one and a half years after receiving a fine or participating in Option 4 than offenders who were 50 or older (Table 4.2). Additionally, offenders who had two or more violations (HR = 2.68, 95% CI: 1.60, 4.49), and/or at least one collision (HR = 3.24, 95% CI: 1.31, 8.02) in the past two years were groups most at risk in experiencing a subsequent collision than those who did not (Table 4.2). On the other hand, living in an urban community (HR = 0.26, 95% CI: 0.08, 0.81), and area where the median household income is between $75,000 - $99,999 (HR = 0.36, 95% CI: 0.17, 0.77) was protective against

future collisions compared to living in rural communities and areas where the median household income was > $125,000 (Table 4.2).

In the multivariate Cox's proportional hazard model, the directionality of all the variables did not change and all the significant variables, except for prior history of collisions (AHR = 1.63, 95% CI: 0.65, 4.16), retained their statistical significance (Table 4.2). No statistically significant interactions were present. A final adjusted survivor function plot incorporating our final model confirmed no statistically significant differences ($p > 0.05$) in time to subsequent collisions between those who received a fine and those who completed an option 4 workshop (Figure 4.3).

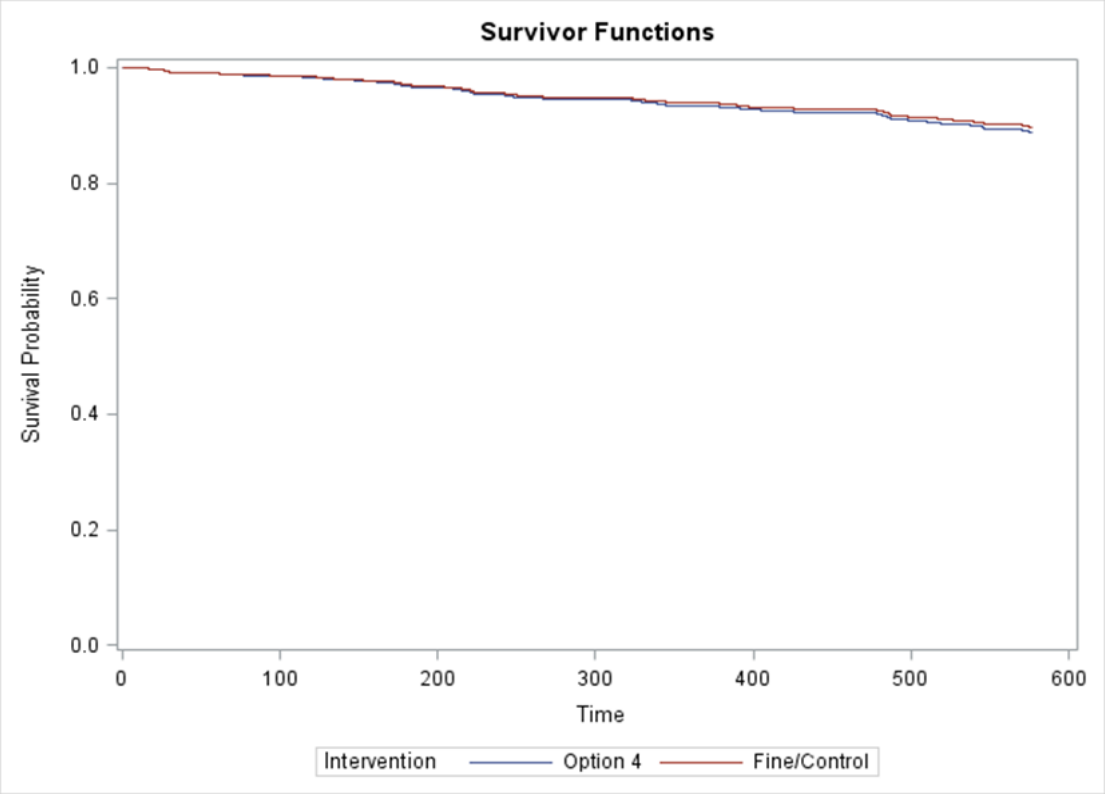

Figure 4.3: Adjusted survival curve utilizing the final main effects collision model

During the purposeful selection procedure, given the lack of confounders present, a reduced model was selected, and the intervention variable (Option 4, Fine/Control) was found insignificant ($p > 0.05$) and not included when calculating the adjusted hazard ratios. In a

supplementary analysis, the intervention variable was trichotomized and the offenders in the fine (choice) group were set as the reference group (0 = Fine - choice, 1 = Option 4, 2 = Fine - Mandatory). Tests for proportional hazards revealed that the trichotomous intervention variable did not violate the PH assumption. When adjusted for our predictors in the reduced model only the control group was significant (AHR = 0.57, 95% CI: 0.34, 0.96) as opposed to the education group (AHR = 0.87, 95% CI: 0.47, 1.63). In other words, offenders who did not have the opportunity to participate in an Option 4 workshop and instead only received a fine had a significantly less likelihood of being involved in a collision at some point one and a half years after receiving their fine than offenders who chose to receive a fine.

4.6 Discussion

Results from this study did not support our hypothesis that participation in Option 4 reduced future risk of traffic collisions relative to receiving a fine. However, mandatory receipt of a fine (without the choice to participate in Option 4) was associated with a lower risk of future crashes compared to offenders who chose to receive a fine instead of participating in Option 4. Specifically, offenders who received a mandatory fine without the option to participate in the Option 4 program had a 43% less chance of having a future collision when compared with offenders who did have that choice.

The current findings align with prior research that has found a lack of effectiveness of educational workshops on future risks of collisions but was the first to compare the impact of choosing to receive a fine versus mandatory fines (Barrett, 2018; Kloeden & Hutchison, 2006). Despite both groups (fine-choice, fine-mandatory) being exposed to the same intervention (i.e. fines), differences between these two groups may be understood under the deterrence theoretical framework. Offenders who when offered the opportunity to not pay a fine in exchange for

educating themselves on traffic safety are a group of offenders who may be least affected by enforcement efforts and least receptive to safer driving instruction. These offenders may see fines as an inconvenience, thus making fines lose their deterrent qualities and thereby increasing their risks for future collisions (Li et al., 2011; Zaal, 1994). They may be guided by their self-interest by seeing the benefits of paying a fine online as outweighing the costs of spending an hour or so learning about traffic safety (Paternoster, 2010).

Despite our limitations, the current study adds value to traffic safety research in several ways. Prior studies (Chapter 2 and 3) found that the community of where the offender resided (Urban vs. Rural) was a non-significant predictor of either choosing to participate in Option 4 or future traffic violation risk. However, the current study found evidence that living in urban areas, compared to rural areas, considerably reduced one's odds of being involved in future collisions substantiating much of the prior literature conducted within and outside of Alberta (Blatt & Furman, 1998; Kmet et al., 2003; Zhang et al., 2013). Prior evaluations failed to take this predictor into consideration which could have impacted their findings (Kloeden & Hutchison, 2006; Villaveces et al., 2011). Our study provides evidence that assessing residency is an important factor to consider when testing for Option 4 efficacy or other similar workshops in future evaluations and studies.

4.7 Study Limitations

The current study may have suffered from certain shortcomings given that a very small number of offenders experienced collisions (5%) one or so year(s) later (Table 7). Wåhlberg's (2018) conclusion that DIPs are ineffective in reducing collision risk noted that prior studies suffered from relatively poor methodologies and may have as a result underestimated the effects of DIPS on collision risk. As such, our study may have potentially underestimated the effect of

both the Option 4 and fine intervention due to our short follow up time. Additionally, given that only 78 offenders experienced a collision within one and a half years of being followed up, we could have only incorporated a maximum of 8 predictors in our model which prevented us from incorporating other very important variables such as how many hours per week offenders spend behind the wheel and weather conditions (Table 7). We also could not include these variables due to data unavailability. We also did not assess collision severity (i.e fatal versus minor collisions) but rather general collisions which, could have also impacted our findings.

Additional limitations present in the current study may have also contributed to information and selection bias. Since our study relied on reported records of traffic collisions rather than directly observing offenders for one year, our current study did not consider unreported collisions. Thus, the percentage of individuals experiencing a subsequent collision is likely underestimated in this study. Additionally, there is a risk that offenders may have driven to other provinces and/or countries and could have experienced a collision. Data pertaining to these types of events would not be collected by the databases (the Enforcement Services Records Management System, JOIN, PROS) and thus not incorporated in the analysis while no scholarly work has been conducted to validate these databases. The current study is also prone to selection bias as individuals stopped during the campaign dates could select whether they would receive a fine or take the educational workshop which, increased the likelihood of self-selection bias (Kloeden & Hutchinson, 2006).

Despite the limitations, all databases contain the most up to date and complete traffic information for all licensed Albertan traffic offenders. Additionally, the PROS and JOIN databases are routinely used by police departments in the province to assess for violation and collision history. Given the severity of the event (collisions) it is likely that law enforcement

personnel were notified of the event and would be captured in the previously mentioned databases. As such, the number of missed collisions is likely small. To minimize data entry errors, a second-team member randomly checked 10% of entered records to ensure data entry was accurate and contained no data entry errors.

4.8 Conclusion

The current study is the first cohort study to directly compare time to subsequent collisions between offenders who received an educational workshop or a fine in a sample of Canadian offenders. Despite a lack of evidence suggesting that Option 4 is effective in reducing subsequent traffic collisions, findings from our study concluded that offenders living in rural areas, and those who were younger than 19 and with 2 or more prior driving violations two years prior to being stopped were most at risk for future collisions after receiving a fine or participating in an Option 4 workshop. As such, interventions tailored to reducing risks of future collisions in Alberta should focus on tailoring efforts to these at-risk groups. While there is evidence to suggest that those who received a fine, without the ability to participate in Option 4, had the lowest risk for later collisions future work can address the limitations present in our study and hopefully determine which strategy (educational or fine) decreases the risk of future collisions.

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Chapter 5: General Discussion

Recent evidence has suggested that Strathcona country continues to suffer a disproportionate number of collision relative to other Albertan jurisdictions. Within the last decade, the average annual collision rate in Strathcona County roads increased from 13.66 in 2011/2013 to 35.7 in 2017/2018 (per 100,000) (Rawson & Narbonne, 2018). As such, the need for evidence-based interventions to address this issue is a pressing need. Since 1988, Option 4 has been conducted in various Albertan municipalities by RCMP and other law enforcement personnel and has the potential of being used as an evidence-based adjunct to standard law enforcement in improving traffic safety (Narbonne, 2017). Although Option 4 has been very well received by attendees and has enhanced relations between policing and the Strathcona County community, the research reported in this thesis was the first attempt to establish its effectiveness in improving traffic safety. Specifically, this thesis was interested in determining which group of traffic offenders were interested in participating in Option 4 as well as whether participating in Option 4 reduced the risk of future traffic violations and collisions.

Study 1 identified correlates of participation in the Option 4 workshop relative to offenders who instead chose to receive a fine. Over half of offenders (53%) lived in middle to high middle-class communities (Median household income $100,000 to $124,999) and had higher odds of choosing to participate in an Option 4 workshop than those who lived in high income communities (> $125,000). Differences in whether to choose to receive a fine or participate in an Option 4 workshop were observed among age groups and those who committed one or more violations two years before choosing one of the interventions. Offenders who committed a distracted driving and/or failure to stop at a stop sign violation 2 years before being stopped during one of the campaigns were more likely to participate in Option 4 programming

while offenders in their twenties and those who committed a violation defined as “Other” were less likely to participate in Option 4.

While Study 1 is one of the first in the literature to assess which groups of traffic offenders are more likely to participate in a driver improvement program (DIP), there are several limitations present. Given our quantitative approach, our interpretation as to why offenders chose to participate in Option 4 is speculative at best. The lack of qualitative methodology in Study 1 did not allow us to thoroughly explore what may motivate a traffic offender to participate in Option 4 as opposed to receive a fine. As such, future evaluations may improve upon our work by measuring why someone may be interested in participating in an Option 4 workshop using surveys or qualitative interviewing.

In Study 2, results from multivariate Cox’s regression analyses revealed that participation in Option 4 prospectively reduced the risk of violations one or so year(s) later. Additionally, female offenders and offenders who committed one or more violations two years prior of being stopped were groups most at risk for future violations while offenders who lived in communities where the Median household income was between $75,000 and $124,999 were groups least likely to commit a follow up violation when compared to offenders living in high income communities (> $125,000). We also found evidence that the effectiveness of Option 4 programming is dependent on the age and sex of the offender. More specifically, Option 4 programming is ineffective among Male offenders as well as offenders between the ages of 16 and 26. However, Option 4 programming is an effective intervention in reducing the risk of future violations among female offenders and offenders who are older than 27 with the risk for future violations decreasing every 10 years an offender gets older.

Study 2 is the first Canadian research to assess risk of subsequent violations as well as the first prospective study to utilize survival analysis in a Canadian context to test for future violations when compared to standard enforcement interventions with educational workshops. Our study serves as a blueprint for future evaluations on Option 4 as well as other workshops across the country in terms of how to evaluate its effectiveness as well as which variables to account for. Nonetheless, our study suffers from several methodological issues. First, several variables were not accounted for that were utilized in prior evaluations that could have potentially altered our results (Barret, 2018). Based on results from our first study, we found numerous group differences between those who chose to receive a fine and those who chose to participate in Option 4 which prevents us from ascribing reduction in violation risk entirely to Option 4 despite controlling for those variables in our multivariate models (Kloeden & Hutchinson, 2006).

Replicating the survival methodology in Study 2, we sought to determine whether participation in Option 4 was associated with a lower risk of future collisions one and a half years later in our third study in Study 3. Results indicated that there was no evidence that exposure to Option 4 reduced risk of future traffic collisions. Instead, when compared to offenders who chose to receive a fine, offenders who were given a fine without the opportunity to participate in Option 4 had the lowest risk for collisions one and a half years after. Offenders who were stopped in the second campaign were less likely to be involved in a collision one year later, probably due to a shorter follow up period than those in the first campaign, while offenders who had two or more traffic violation two years prior to being stopped were more likely to be involved in a collision. Yet, unlike our study in Chapter 3, we found that offenders who lived in urban communities, as compared to rural communities, were less likely to be involved in a

collision and offenders who were 19 years or younger were the group most likely to be involved in collisions than older offenders (> 50).

Our third study however suffered an issue that is common in the literature, namely a low number of outcomes (i.e. collision). A similar issue arose in Barrett (2018) who failed to find an effect of workshops due to the small number of collisions that were available for analysis. The issue that plagued his study also plagued our own. In addition to the small number of collisions, our analysis also failed to find a significant relationship between completion of the Option 4 workshop and reduction in follow up collisions. Based on recommendations from Barrett (2018) increasing the sample size of offenders and increasing the follow up period from one and a half years to three or five years can help future research and evaluations as well.

5.1 General Limitations

A number of limitations in relation to selection bias are present in the current thesis. The designs for each study are prone to self-selection bias. Individuals stopped during the campaigns could select whether they would pay a fine or take the educational workshop thus allowing the potential for self-selection bias to enter the study (Kloeden & Hutchinson, 2006). Additionally, given that no law enforcement personnel were surveyed to ensure that every offender was given the opportunity to participate during the campaign dates, there may be an issue that only offenders whom the officers deemed “respectful” or whom they felt could benefit the most from Option 4 were given the opportunity to participate. As such, participants in the option 4 group may be offenders who under normal circumstances are more easily deterred from committing future violations and/or have a lower risk of being involved in a collision regardless if they completed the Option 4 workshop or not.

There are multiple data limitations present in the current thesis as well which could have also led to information bias. First, due to data unavailability, our study was unable to control for important variables such as miles travelled, number of years that offenders were licensed, and demerit points, as well as how fast offenders were traveling which, are predictors of future violations (Barrett, 2018; Li et al., 2011). Secondly, all data was manually entered by the Strathcona Enforcement team which could have led to data entry errors. Additionally, since our study relied on reported records of traffic violations and collisions rather than directly observing offenders for one year, our current study did not consider unreported violations and collisions which impacted other traffic safety studies that used policing databases or self-reports of traffic violations and/or collisions (Elias, 2018; Lawpoolsri et al., 2007; Li et al., 2011; Wåhlberg, 2010). Thus, the percentage of individuals committing a subsequent violation or collision is likely underestimated in this study given that most violations, particularly speeding, are not recorded by law enforcement personnel (Li et al., 2011). Lastly, there is a risk that offenders may have driven to other provinces and/or countries and could have committed a violation or have been involved in a collision. Data pertaining to these types of events would not be collected by the databases (the Enforcement Services Records Management System; JOIN; PROS; ROADS) and thus not incorporated in the analysis.

Despite the limitations present a number of steps were undertaken to control for these biases. In regards to selection bias, the ideal situation would be to randomly assign the participants into the treatment and control groups (i.e. workshop or fine) without allowing the offenders to choose so as to prevent any type of selection bias from occurring in the first place (Kloeden & Hutchinson, 2006). However, the legal and ethical contentious nature of such strategy precluded one to allocate the participants in such manner. In other words, the ethical and

legal costs that would result from assigning participants to the option 4 workshop would outweigh the benefits to the study participants and the integrity of the study. In order to remedy this situation, a control group was established which contained offenders who were only given a fine as a means of controlling for self-selection bias. Receiving fines or warnings, based on the discretion of the officer, is standard law enforcement procedure and would be conducted whether or not a law enforcement campaigns was occurring.

While there were issues evident within our databases, the data sources used in this study contain the most up to date and complete information pertaining to all driving incidents for all licensed Albertan offenders and are the databases used by policing services across the province. To minimize data entry errors, a second team member manually checked 10% of randomly chosen records to ensure data entry was accurate and contained no data entry errors. The second team member confirmed that the data entered was accurate. Lastly, while a number of variables were considered, we tested and avoided overfitting and multi-collinearity from occurring and unlike the majority of studies in the literature we incorporated a diverse number of important environmental sociodemographic and driver history variables.

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Chapter 6: Public Health Implications/Recommendations

The current study is not only the first to evaluate the Option 4 program but the first study within Canada to compare the risk for subsequent violations and collisions for those who completed an educational workshop on traffic safety versus those who received a standard fine. Additionally, our study is one of the few to our knowledge that incorporated a control group (i.e. group not offered a fine) that allowed for a direct comparison between two oppositional interventions routinely discussed in the literature on various outcomes (i.e. traffic violations and collisions). Despite the data and study limitations previously discussed, the results produced in each of our three studies are novel and widespread.

Regarding our first objective, we found that varying pre-existing offender, community, and seasonal characteristics were associated with attendance to an Option 4 workshop. These findings may be used to better understand who may be more inclined to participate in an Option 4 workshop or receive a fine as well as target advertising, to increase buy in, to these groups as well. For example, law enforcement officials can increase the number of traffic campaigns, where Option 4 is available for drivers to participate, in communities where the median household income is between $100,000 and $125,000 as well as during the fall season. Officials can also target online advertising on municipal and government websites where offenders pay fines, particularly those who commit failure to stop at a stop sign and distracted driving offences. The second study provides evidence that Option 4 is an evidence-based intervention in reducing future violations. Our study first identified risk factors that are associated with future violations which are paramount in the establishment of effective programming in collision and violation reduction (Zhang et al., 2013). Next, our study evaluated whether Option 4 programming reduced follow up violations. Our results confirmed that participation in an Option 4 workshop

significantly reduced the risk of future violations by 44% compared to offenders who only received a standard law enforcement traffic ticket. The effect of Option 4 was especially present in female offenders and offenders older than 27. Rather than explicitly relying on standard law enforcement measures that could tax extra resources, Option 4 can be considered a cost-effective intervention and our study provides evidence that this intervention should be expanded across the province. Yet unlike in our prior study, our third study confirmed that within the Albertan context, educational programming has no effect in reducing the risk for future collisions. Instead those who received a fine, without the opportunity to participate in Option 4, had the lowest risk for future crashes compared to those who willingly chose a fine. However, this finding may be attributed to a group (fine-choice) of offenders who are least likely impacted by law enforcement programs and least likely motivated to participate in a traffic safety workshop or adhere to traffic laws.

6.1 Future Research

According to Wåhlberg (2010, 2013), most English studies assessing effectiveness of educational workshops on traffic safety suffer from methodological issues. As such, future research can improve upon the work presented here in many ways.

For study one, integrating the beliefs, motivations, and lived experiences of traffic offenders would provide more context and information regarding what may motivate someone to participate in an educational workshop. Future research could incorporate validated and reliable driver questionnaires, such as the Driver Behaviour Questionnaire (DBQ) and the Driver Attitude Questionnaire (DAQ) that assess driver beliefs and motivations prior to and after participating in an Option 4 workshop in order to arrive at more thorough and well-grounded conclusions (Wåhlberg, 2010). Future research could also integrate qualitative methodologies

such as interviews or focus groups, in conjunction with surveying attendees, to ascertain why individuals would choose to participate in Option 4 or receive a fine (Barret, 2018).

For study 2, future evaluations of the Option 4 program can increase the follow up time from one and a half years to potentially three years to assess the long-term effects of driver improvement programming as Barrett (2018) had done. Additionally, models should consider incorporating a wide variety of other environmental and vehicle confounders, not explored here, to effectively test whether the effectiveness of Option 4 is diminished when considering these other variables. Secondly, future work can also improve on the design of our study by randomly assigning traffic offenders into either the educational or fine groups, without allowing offenders to choose their interventions of choice, reducing the risk of selection bias as well as greater confidence in attributing reductions to traffic violations to educational interventions (Kloeden & Hutchinson, 2006). Future research could also explore whether option 4 programming has had a specific reduction in specific violations rather than general violations as we have done here. In other words, future research can potentially answer the following questions: did option 4 workshops that targeted speeding behaviour reduce subsequent speeding violations among participants as compared to general violations? Lastly, future studies can also decompose types of traffic violations stratified by various predictors including sex. Similar recommendations from study 2 can also be incorporated for study 3 including increasing follow up times, especially given the low number of collisions during our study period. Lastly, future investigations can incorporate variables that our study failed to incorporate, due to data unavailability, including collision severity, weather conditions, and other important predictors of collisions.

6.2 Recommendations

Given our results from study one, gaining insights from groups who may not be motivated to participate in a workshop (i.e. offenders in their twenties) as to how Option 4 can be more appealing would assist program designers towards making Option 4 appeal to a wider audience. Simultaneously, Strathcona County could also target advertising to populations who are motivated in participating in Option 4 (i.e. those living in communities where the Median household income is $100,000 to $124,999) and during certain times of the year (i.e. the fall season) which would increase the probability that more people be would exposed to traffic safety programming.

Based on our findings in our second study, it is recommended that Strathcona Enforcement services not only continue to operate Option 4 within their jurisdiction but that they and other Albertan municipalities expand Option 4 programming. Given that our results showed that females had a higher risk of future violations than men, and participation in the Option 4 significantly reduced their risk, encouraging female offenders to participate is critical in reducing their risk for subsequent violations. Additionally, offenders 27 years or older should also be encouraged to participate as Option 4 programming was effective amongst this population compared to those who were younger. To increase the number of participants exposed to Option 4, it may be advisable to utilize statistical forecasting techniques (i.e. Time Series Forecasting, etc) to identify seasons and weeks where the incidence of violations may be the highest. By identifying the times and locations of where violations tend to peak in Strathcona County, the probability of enrollment to Option 4 will likely increase. Greater numbers of offenders exposed to Option 4 will then lead to an even greater reduction in future violations. Additionally, Strathcona County can also host voluntary Option 4 workshops for female non-offenders and

those older than 27 prior to their first offence to further decrease the incidence of future violations.

We feel that the practice of issuing fines should be continued by enforcement services as there is some evidence that they may reduce future collision risk. Similar to our prior recommendations with violations, identifying peak times and seasons where collisions are more likely to occur in Sherwood Park and conducting traffic operations and implementing fines during these times may increase the number of offenders receiving fines and thus lead to a greater number of offenders reducing their risk of collisions. To potentially improve the effectiveness of fines in reducing future risks of collisions, several steps can be undertaken based on recommendations from prior research. Using a deterrence theoretical framework, increasing the severity of the punishment (i.e. increasing fine amounts) can be seen as an effective measure in improving the effectiveness of fines. A recent meta-analysis revealed that increasing fixed-fine amounts (50% to 100%) has a statistically significant small effect on reducing future violations with fine increases beyond 100% having no effect on reducing violations (Elvik, 2016). The review also found that increases in fines were associated with small reductions in crashes (5-10%) (Elvik, 2016). Secondly, some studies have found that rather than being used in a consistent and effective manner to correct future problematic driving behaviour, monetary fines are instead used as a tool to generate municipal revenue that would offset government deficits in areas that have experienced revenue scarcity or fiscally stringent taxes and policies (Garrett and Wagner, 2009; Makowsky and Stratmann, 2009; Luca, 2015). Rather than focusing on improving road safety, officers whose incentives lie in increasing revenue for local governments will lead to an asymmetrical issuement of fines thereby reducing the deterrent effects that fines may have in deterring future problematic behaviour (Garrett and Wagner, 2009; Makowsky and

Stratmann, 2009; Luca, 2015). Thus, ensuring that fines are implemented in a consistent manner may improve their effectiveness.

As Strathcona County approaches 2021, the need for evidence-based strategies in making Strathcona County roads safer becomes ever more apparent. This study found evidence that Option 4 programming is one such initiative that can play a role in reducing the risks of individuals incurring future violations by teaching them traffic safety protocol while some evidence may suggest that fines, while ineffective in reducing future violations, can play a role in reducing future collisions. Taken together, both interventions can work collaboratively with one another to ensure that "No one is seriously injured or killed while travelling on Strathcona County's road network" (Rawson & Narbonne, 2018, p. 3).

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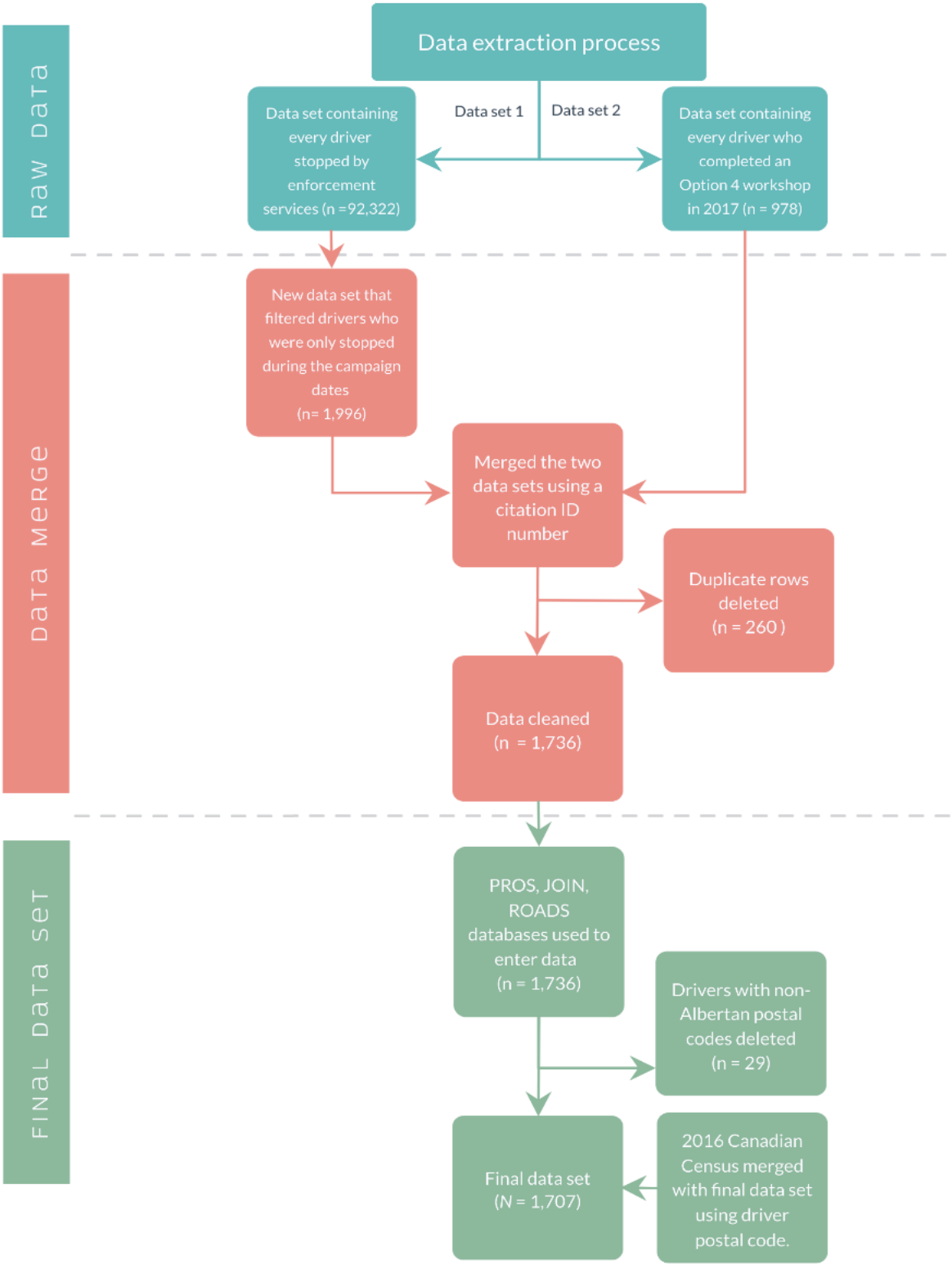
Appendix A: Data Extraction Process



Appendix B: Variable codes

Demographic

Age Group: (**0** = *< 19*, **1**= *20-29*, **2** = *30-39*, **3** = *40-49*, **4** = *> 50*)

Age: (Continuous)

Sex: (**0**=*Male*, **1**= *Female*)

Community

Area median income: (**0** = *$48,000 - $74,999*, **1**= *$75,000 - $99,999*, **2** = *$100,000- $124,999*, **3** = *> $125,000*)

Geography of Residence: (0 = *Urban*, **1 =** *Rural*)

Prior Driver History

Prior speeding violation (Last 2 Years): (0 = *0*, **1 =** *1*, **2 =** *>2*)

Prior failure to stop at a stop sign violation (Last 2 Years): (0 = 0, 1 = 1, 2 = >2)

Prior distracted driving violation (Last 2 Years): (0 = 0, 1 = 1, 2 = >2)

Prior other traffic violation (Last 2 Years): (**0** = *0*, **1** = *1*, **2** = *>2*)

Prior total traffic collisions (Last 2 Years): (**0** = *0*, **1** = *1*)

Prior total violations (Last 2 Years): (**0** = *0*, **1** = *1*, **2** = *>2*)

Intervention

Campaign/Season: (**0** = *Campaign 1*, **1**= *Campaign 2*)

Intervention: (**0** = *Fine/Control*, **1**= *Option 4*)

Outcomes

Intervention chosen (Study 1): (0 = Fine, 1= Option 4)

Follow-Up Violation (Study 2): (**0** = *No 1*, **1**= *Yes*)

Follow-Up Collisions (Study 3): (**0** = *No 1*, **1**= *Yes*)

Appendix C: (Tests between Fine and Education Group)

Violations

Test of Equality over Strata			
Test	**Chi-Square**	**DF**	**Pr > Chi-Square**
Log-Rank	43.1136	1	<.0001
Wilcoxon	40.5955	1	<.0001
Tarone	42.1284	1	<.0001
Peto	41.4607	1	<.0001
Modified Peto	41.4584	1	<.0001
Fleming(1)	41.4613	1	<.0001

Collisions

Test of Equality over Strata			
Test	**Chi-Square**	**DF**	**Pr > Chi-Square**
Log-Rank	0.1512	1	0.6974
Wilcoxon	0.3887	1	0.5330
Tarone	0.2747	1	0.6002
Peto	0.1646	1	0.6850
Modified Peto	0.1648	1	0.6848
Fleming(1)	0.1643	1	0.6852