ASSESSING THE EFFECTS OF THE IGNITION-INTERLOCK DEVICE ON RECIDIVISM

by

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ABSTRACT

In 2012, there were 10,322 traffic fatalities in the U.S. involving at least one driver with a blood-alcohol concentration (BAC) of .08 or higher. This was roughly 31% of all traffic fatalities that year (National Highway Traffic Safety Administration, 2013a). The ignition-interlock device is one intervention method to reduce driving while intoxicated. The present study evaluates the ignition-interlock device's effect on DWI recidivism when used during different post-arrest phases, including pretrial, probation, and combined pretrial and probation. Propensity score matching is used to account for the selection bias commonly present in observational studies of DWI offenders. Results indicate the ignition-interlock device has a negative effect on the risk of and time to DWI recidivism during certain post-arrest time periods. Implications for policy and future research are discussed.

I. INTRODUCTION

In 2012, there were 10,322 traffic fatalities in the U.S. involving at least one driver with a blood-alcohol concentration (BAC) of .08 or higher. This was approximately 31% of all traffic fatalities that year (U.S. Department of Transportation, 2013a). Since the Highway Safety Act in 1966, lawmakers have addressed this public safety issue through publicity for sober-driving efforts, stricter blood-alcohol levels, and greater punishment for those who commit driving-while-intoxicated (DWI) offenses (Lerner, 2011). Use of alcohol-monitoring technology after arrest is one method of punishment commonly used for DWI offenders. The relationship between prior intoxicated driving and traffic fatalities indicates a need for examination of this criminal justice intervention that seeks to reduce DWI recidivism (DeMichele & Payne, 2010).

Driving While Intoxicated

DWI offenses involve a person suspected of driving a vehicle with a BAC of .08 or higher (Governor's Highway Safety Association, 2014). DWI and driving-under-the-influence (DUI) criteria vary across states by type of intoxicant (alcohol or drug), charge level, and punishment. In 2012, the National Survey on Drug Use and Health reported that 3.9% of respondents reported driving under the influence of an illicit drug, and 11.2% reported driving under the influence of alcohol. This corresponds to an estimated 39.4 million intoxicated drivers in that year (U.S. Department of Health and Human Services, 2013). Depending on the jurisdiction, a prior DWI conviction or a high BAC at the time of arrest will lead to an enhanced DWI charge from either a class B misdemeanor to class A, or a class A misdemeanor to a felony. Those convicted of DWI

are 80% more likely to be involved in a fatal collision, compared to those who are not (Marques & Hodgins, 2014). Of the total pool of DWI offenders, about one-fourth commit DWI more than once (Warren-Kigenyi & Coleman, 2014). Those with prior DWI convictions are 1.4 times more likely to be involved in a traffic fatality than first-time offenders (National Highway Traffic Safety Administration, 2000).

The prevalence of alcohol-related DWI and multiple DWI offending, coupled with the increased risk of traffic fatalities, has led to implementation of a variety of corrective measures for those who commit DWI. All states have some type of law aimed at preventing DWI. These laws include law enforcement policies aimed at detecting drunk driving, such as sobriety checkpoints and no-refusal initiatives. To reduce drunk-driving, recidivism laws have been implemented that restrict an offender's access to a vehicle, monitor his/her alcohol consumption, or alter driving behaviors (Sylvester & Haider-Markel, 2015). Nationally, the two most common DWI recidivism-reducing methods are license suspension and the ignition-interlock device. License suspension is an administrative punishment usually involving suspension of driving privileges for at least 90 days (Governor's Highway Safety Association, 2014). License reinstatement is often conditional on use of the ignition-interlock device while on bond or serving a probation sentence.

Alcohol-monitoring technology, such as the ignition-interlock device, is used to prevent a person from driving a vehicle while under the influence of alcohol. All 50 states have some type of interlock requirement, ranging from a general order for all DWI offenders (first-time or multiple), to high BAC, or multiple DWI offenders (Governor's Highway Safety Association, 2014). Ignition-interlock device laws often require

offenders to install a breath sensor on their vehicle, which records their BAC when starting the vehicle and while driving at 20- to 30-minute intervals. Interlock laws also require a usage report and inspection for device tampering or circumvention every 30 to 60 days (National Highway Traffic Safety Administration, 2010).

There are many state-level factors that influence the implementation of DWI policies, such as the occurrence of DWI offending, the amount of DWI-related traffic fatalities, and the available resources to implement or change policy (Baumgartner, Green-Pederson, Jones, Mortensen, Nuytemans, & Walgrave, 2009). Federal interests also play a role in state-level, DWI correctional policies through the provision of highway funding. Federal statute 23 U.S.C. § 164 requires states to enforce the minimum guidelines for ignition-interlock programs. According to these guidelines, use of an ignition-interlock device is required for DWI offenders with prior DWI convictions, as recommended by the National Highway Traffic Safety Administration or NHTSA (U.S. Department of Transportation, 2013b).

Failure to meet the requirements of this federal statute will result in revocation of federal highway funding from the Highway Trust Fund (HTF). Failure to comply with the federal interests aligned with the HTF can be significant for states' transportation resources. The HTF provides a large amount of funding for state roads and highways for maintenance and construction through state contracts with the Federal Highway Administration (FHA) (Cawley, 2013). In 2012, the FHA granted approximately $33 billion in funds. States have an increasing reliance on these funds due to gas price fluctuation and reluctance to increase gas taxes. FHA funds in 2013 amounted to $44 billion nationally, a 30% increase from the prior year (Cawley, 2013).

Interlock Laws, Pretrial, and Probation

Ignition-interlock programs require participants to install alcohol-monitoring technology, most commonly the ignition-interlock device. Less frequently used devices include a portable alcohol-monitoring device (PAM) or a transdermal alcohol sensor. These devices measure intoxication using a person's breath or perspiration. This technology is primarily used in correctional environments to enforce a court order to refrain from alcohol use. During the pretrial phase, this court order is added as a condition of bond release, as a condition of license reinstatement, or as a condition of a pretrial diversion program. During the probation phase, this court order is added as a condition of a probation sentence.

Enforcement of ignition-interlock programs during both post-arrest, pretrial, and probation phases is advocated by federal agencies, such as the NHTSA. The NHTSA communicates its recommendations for ignition-interlock programs through its published guidelines. These recommendations suggest that all individuals convicted of DWI, including first-time offenders, should be required to install an ignition-interlock device and that eligibility requirements that limit offenders' participation in the program be minimized (U.S. Department of Transportation, 2013b). This recommendation relies on recent findings that mandatory use of the ignition-interlock device will reduce the likelihood and rate of re-offending for first-time offenders while the device is installed (Roth, Voas, & Marques, 2005; McCartt, Leaf, Farmer, & Eichelberger, 2013).

Current state-level legislation focused on pretrial services seeks to expand ignition-interlock programs for alcohol-related offenders. For example, new Washington state legislation has called for ignition-interlock device requirements for all DWI

offenders (Wash. SB 5912 § 46.55.360, 2013). Texas has also recently modified its penal code to require those with a BAC of .15 or higher to use an alcohol-monitoring device during pretrial release (Tex. Penal Code § 49.01, 2001). Additionally, there were seven pretrial legislation actions in 2013 across the country that focused specifically on alcohol-related offending and pretrial supervision (National Conference of State Legislatures, 2013).

The minimum standard required for states to meet the ignition-interlock program and to continue receiving HTF funding is imposition of the ignition-interlock device on repeat DWI offenders. Most states, however, have enacted legislation that exceeds this minimum standard of ignition-interlock programs. Five states meet this minimum standard without any additional requirements; 19 meet it, also requiring the ignition-interlock device for license reinstatement; and 26 states meet it by requiring all DWI offenders to use an ignition-interlock device as a condition of a probation sentence (National Conference of State Legislatures, 2014). This dissertation evaluates the ignition-interlock device's effectiveness on recidivism in one county in Texas. Those with a prior DWI conviction are ordered to install an ignition-interlock device within 30 days after arrest unless the condition is removed at a judge's discretion. Those with this order are subject to license revocation if it is not satisfied and pay license eligibility fees (Tex. Administrative Code § 19.21, 2006).

Pretrial and Probation

Pretrial and probation supervision procedures and methods are continually evolving with new laws and policies. During this evolution, in the last 40 years, there have been two significant milestones that have formalized the pretrial release process.

The first milestone occurred in 1974 with the Speedy Trials Act. This was responsible for establishing the first 10 pretrial-services agencies in the United States (Speedy Trial Act, 1974). The second milestone followed almost a decade later with the Pretrial Services Act of 1982. This allowed for pretrial-services agencies to be established in all jurisdictions in the U.S. (Pretrial Services Act, 1982).

Pretrial supervision seeks to reduce a person's likelihood of re-arrest and ensure return to court. The formalization of the pretrial-release process has allowed for these goals to be clearly defined. These goals include appropriate assignment of bonding conditions, defendant notification of upcoming court dates, educating defendants about requirements of bond, and timely enforcement of non-compliance (Goldkamp & White, 2006). These goals increase the likelihood of return to court for scheduled appearances and reduction or elimination of re-arrest during pretrial release.

The time marker for the achievement of the goals of pretrial-services agencies is a defendant's case disposition. Although the method used to achieve these goals often varies, pretrial-services agencies will commonly use some form of deterrent, incapacitating, or rehabilitative methods (Goldkamp & White, 2006). Often, the longevity of the effects of these methods on an offender's likelihood to re-offend exceeds the case disposition.

Pretrial supervision can involve a variety of supervision methods to affect a person's likelihood to offend and return to court. These methods are imposed as conditions of bond, and consequences of non-compliance are often revocation of bond. Pretrial-services agencies are tasked with monitoring compliance with a person's conditions of bond and reporting any violation to the court. These conditions may

include required office visits, use of electronic monitor or the ignition-interlock device, and treatment (Mahoney, Beaudin, Carver, Ryan, & Hoffman, 2001).

Probation supervision has changed in recent decades through increased use of evidence-based practices. This change involves the introduction of research to probation supervision including both implementation of new probation practices and the evaluation of the effectiveness of practices already in use (Alexander & VanBenschoten, 2008; Paparozzi & Gendreau, 2005; Taxman, Thanner, & Weisburd, 2006). The increasing formality of the pretrial-release process and recent introduction of evidence-based practices provide the opportunity for greater insight into the effectiveness of these post-arrest phases.

The primary goals of all probation agencies are to enable successful completion of the probation sentence, protect community residents from re-offending by those serving probation sentences, and to reduce the likelihood of further offending after sentence completion (Baber, 2010). Similar to pretrial-services agencies, probation agencies employ a variety of supervision methods for deterrence, incapacitation, and rehabilitation. Probationers are often supervised in-person, by phone, and/or mail. Probation monitoring authorities oversee compliance with conditions of probation, including completion of assigned community service hours, payment of fees, attendance and participation in court-mandated treatment, maintenance of employment, compliance with monitoring technology, both electronic or alcohol, and re-arrest (Bonczar & Herberman, 2013). More is known about the lasting effects of these supervision methods due in no small part because of the increased use of evidence-based practices.

Study Purpose

The enforcement of DWI and use of effective intervention methods for DWI offenders are important in addressing this public-safety issue. Because DWI is so prevalent across the nation, the federal government has put in place financial incentives to enforce ignition-interlock programs for DWI offenders. To fully understand the implications of such programs, there should be consideration of both pretrial and probation phases for DWI offenders. This study, therefore evaluates the effects that use of the ignition-interlock device during the pretrial and probation, post-arrest phases may have on a DWI offender's likelihood to re-offend.

This study examines the offending behavior of 1,970 persons arrested for DWI, convicted, and sentenced to probation in Travis County, Texas. These persons include male and female offenders who are at least 21 years old, charged with DWI for alcohol-intoxication, and who may or may not have installed or been ordered to use the ignition-interlock device while released on bond and/or during their probation sentence. This study has an intent-to-treat perspective, assessing the installation or order of installation of the device instead of compliance with the device while it is in use. Arrest data are used to track recidivism for one to six years after sentence completion. To reduce selection bias, propensity score matching is used to construct similar treatment and comparison groups. Survival analysis and hazard ratios are used to assess changes in the technology's impact over time, and Cox regression is used to assess the effect this technology has on probation-condition compliance. The results will inform when and how use of this technology may be effective in reducing an offender's likelihood of recidivism.

II. LITERATURE REVIEW

DWI offending has substantial financial and public safety implications in the U.S. As pretrial services for DWI offenders continue to expand and formalize, it is important to assess their effects. Previous studies have focused on probation supervision's effects; yet these study ignore pretrial effects. Using an intent-to-treat perspective, this study seeks to fill this gap by examining the effects of the installation or order of installation of the ignition-interlock device, for both probation and pretrial phases, during a probation sentence, and after sentence termination.

Recidivism

Criminal punishments are administered to achieve different goals. These goals, which are measured in a variety of ways, include specific deterrence, incapacitation, and rehabilitation. These three goals all concern the experience of the offender (Ross, 1989). One must examine the offender's behavior to examine if the goals of punishment have been met.

The concept "recidivism" is often used to evaluate the extent to which many of these goals are achieved – specific deterrence, incapacitation, and rehabilitation in particular. Recidivism has been defined as a reversion to criminal behavior after punishment (Maltz, 1984), yet measurement of recidivism has varied across studies. Debate over how to measure recidivism often focuses on three questions: (1) what constitutes a re-offense? (2) when does the opportunity to re-offend begin? and (3) how long should the follow-up time period be?

The more restrictive measure of re-offending is subsequent offending for the same offense. An alternative measure is subsequent offending for any offense. Selection of the most appropriate measure of re-offending should rely on the goals of the criminal punishment being evaluated (Maltz, 1984). The more restrictive measure, subsequent offending for the same offense, is advantageous for evaluating punishment's effects on specialized offending. DWI offenders often commit only subsequent DWI offenses (Labrie, Kidman, Albanese, Peller, & Shaffer, 2007). This measure can be advantageous for measuring the effectiveness of punishments aimed as changing specific behaviors, such as problem drinking and driving. The disadvantage of this restrictive measure is that it fails to capture versatile offending, such as subsequent offending for different offenses. Many have argued that most offenders do not specialize in the types of offenses they commit; instead, they commit diverse types of offenses (e.g., Gottfredson & Hirschi, 1990; DeLisi, Beaver, Wright, Wright, Vaughn, & Trulson, 2009). Measuring recidivism as subsequent offending for any offense is appropriate for evaluating a criminal punishment with the goal of changing any future criminal behavior.

The decision about when a follow-up time period should begin also relies on the goal of the criminal punishment being evaluated. Evaluation of a punishment with a goal of incapacitation requires observation of the offender while the punishment is being imposed (Maltz, 1984). For example, evaluation of the incapacitating effect of license suspension on DWI offenders has employed follow-up time periods beginning at the time of the order of license suspension (Voas, Tippetts, & Taylor, 1997).

Evaluating recidivism requires the assumption that all individuals have an opportunity to re-offend over the same amount of time. Offenders, however, maintain

different likelihoods of re-offending at different times, making this assumption inappropriate for assessing recidivism and threatening the construct validity of a recidivism measure (Maltz & McCleary, 1977). To avoid this problem, recidivism can be defined as time-dependent and assess the probability that an offender will re-offend over a certain period of time (Stollmack & Harris, 1974). Observing recidivism over a longer period of time is advantageous when assuming time-dependence, because it provides an opportunity to capture more recidivism events.

A longer follow-up time period is also advantageous for evaluation of DWI recidivism because of an offender's dynamic risk factors. DWI criminogenic risks, such as age and criminal history, change over time, so they are dynamic. Consider a one-year fixed recidivism follow-up. This follow-up time period neglects dynamic risk factors that may change over more than a year's time. Increasing the actual follow-up time period beyond one year mitigates this problem because it provides a longer period of time to observe treatment effects (Maltz, 1984). There is a variety of follow-up time periods in the existing literature on DWI recidivism. A recent meta-analysis of DWI-intervention evaluations indicates that follow-up time periods range from 6 months to 15 years. The most common follow-up time period is two years post-intervention (Miller, Curtis, Sonderlund, Day, & Droste, 2015). Ultimately, the goal of the punishment under evaluation should inform what criteria are more appropriate for the recidivism measure.

Theoretical Explanations of Recidivism

Several theories have been used to explain DWI recidivism. Since Ross' (1984a) seminal work on drunk-driving, deterrence has been one of the primary explanations of the effects of drunk-driving interventions. Deterrence is important to drunk-driving

intervention because much of the criminal-justice policy is aimed at deterring future behavior. Deterrence theory is a rational-choice theory that maintains a potential offender weighs the perceived costs of punishment and benefits of crimes (Bentham, 1830). Costs are measured by the certainty, severity, and celerity (swiftness) of legal punishment (Beccaria, 1972).

For the DWI offender, a high certainty of punishment is the most important deterrent (Ross, McCleary, & Epperlein, 1981; Ross, 1993a; Fulkerson, 2003). The British Road Safety Act of 1967 increased the certainty of punishment by allowing law enforcement officials to demand blood-alcohol levels without a legal suspicion of drunk driving. Accompanying this was a one-year mandatory license suspension. The result was a substantial decrease of approximately 800 drunk-driving-related fatalities annually (Ross, 1984b). Severity of punishment is only effective when the perceived certainty of punishment is high (Keane, Maxim, & Teevan, 1993). Policies to increase the severity of punishment through mandatory maximum sentencing have been found to have little to no effect on reducing drunk driving (Robertson, Rich, & Ross, 1973a).

More recent attention has been given to the joint effects of certainty and celerity of punishment on deterring drunk driving. Programs using guaranteed jail time within several days of alcohol non-compliance detection have significantly reduced DWI recidivism (DuPont, Shea, Talpins, & Voas, 2010). The 24/7 Sobriety program required repeat offenders to submit a breath sample twice a day. Detection of alcohol from these samples resulted in a short (two-three day) jail sentence imposed within 72 hours of a violation. High-risk, multiple DWI offenders who participated in the program had an average increase in sobriety of 111 days, while drunk-driving-related crashes were

reduced by 50% (Caulkins & DuPont, 2010). The HOPE program imposed similar consequences for alcohol- or drug-related violations within several days of non-compliance detection (Hawken & Kleinman, 2009). Those not participating in the HOPE program were three times more likely to recidivate and at a faster rate than participants (Hawken, 2010).

It is debatable whether people make a rational assessment of the costs and benefits of a behavior while under the influence of alcohol or drugs. An assumption in deterrence theory of a rigid, cost/benefit calculation based on actual facts instead of perceptions has largely been replaced by bounded rationality. Bounded rationality is a more flexible, "rational" calculation based on imperfect information and the adaptation of people's perceptions from prior experiences (Simon, 1957). An experimental study of alcohol intoxication, aggression, and rational choice found that intoxication does lead to heighten aggressive responses. However, this heightened response was independent of the rational calculation of the elements of the, certainty, severity, and celerity of punishment (Exum, 2002).

In addition to deterrence, incapacitation is often used as an explanation for DWI recidivism. The incapacitating effect of an ignition-interlock device will end when it is removed (Elder, Voas, Beirness, Shults, Sleet, Nichols, & Compton, 2011). The ignition-interlock device can have a similar effect as jail. There is a 60% reduction in DWI recidivism while the device is installed, but the effects degrade, and non-treatment probabilities return soon after it is removed (Roth et al., 2005).

Violation of the interlock device can occur while the device is installed, making this an imperfect incapacitation. Although intoxicated drivers cannot drive an installed

vehicle, they can drive an alternative, uninstalled vehicle (Fulkerson, 2003). The effectiveness of either a deterrent or incapacitation approach is heavily reliant on the predictors of DWI recidivism. These predictors inform what corrective approach criminal justice authorities may use to mitigate potential re-offending.

Predictors of DWI Recidivism

The strongest predictors of DWI recidivism are, measures of past behavior, criminal history and the number of prior DWI's. Other, weaker predictors include age, gender, and race/ethnicity, as well as, social stability measures, such as criminal risk and need, employment, marital status, and number of dependents. The DWI-recidivism literature suggests that criminal history and more specifically, prior DWI arrests, are a strong predictor of future DWI offending. Almost 80% of multiple DWI offenders are "pure" offenders in that they have never committed another type of offense (Marques, Tippetts, & Voas, 2003). Criminal history in general also matters because pure offenders are more likely to be positively affected by treatment than those who have committed diverse offenses (LaBrie et al., 2007). Pure DWI offenders are also of concern because they account for 70.4% of recidivism after removal of the ignition-interlock device (Marques, Tippetts, & Voas, 2003).

Voas, Marques, Tippetts, and Beirness (1999) found that three years after removal of the ignition-interlock device, 15 out of 1,000 first-time offenders committed another DWI, compared to 44 out of 1000 repeat offenders. More recently Rauch et al. (2010) found that within one year of interlock removal, first-time offenders had a 3.6% DWI recidivism rate, compared to multiple offenders whose recidivism rate ranged from 28%-63%. These researchers also found that as both the number of prior DWI's and years

from device removal increased, so too did the rate of DWI recidivism for repeat DWI offenders. Five years after removal of the ignition-interlock device, the recidivism rate for first-time offenders was 3.4%, while it was 42% for those with three or more prior DWI's (Rauch et al., 2010). Furthermore, those with multiple DWI convictions are also more resistant to treatment (DeMichele & Payne, 2010; Taxman & Piquero, 1998).

General criminal history has also been found to predict DWI recidivism. Those with a prior felony conviction have a 33% greater likelihood of DWI recidivism than first-time offenders (Beerman, Smith, & Hall, 1988). The effects of general criminal history, however, are greater for males than females (Donovan, Umlauf, & Salzberg, 1990). Though not as strong as the number of prior DWI's or criminal history, age and gender are significant predictors of DWI recidivism. According to the age-crime curve, offending usually peaks between ages 15 and 17 and then decreases around age 20, continuing to decrease throughout the remainder of the life course (Sampson & Laub, 2003). In contrast, DWI recidivism is least likely for persons under age 20 or over age 50. Those most likely to recidivate for a DWI fall between ages 25 and 40 (Hubicka, Laurell, & Bergman, 2008; Johnson, Gruenewald, & Treno, 1998).

The probability of non-violent or violent offending peaks in the late teens or early 20s (Farrington, 1986), but the average DWI offender is in his/her late 20s or early 30s. First offenders have been found to average between 29 and 32 years of age (Taxman & Piquero, 1998; Cavaiola, Strohmetz, & Abreo, 2007). In contrast, a study of multiple offenders identified average ages of 33 to 38 (DeMichele & Payne, 2010; Schell, Chan & Morral, 2006; Beck et al., 1999). This disparity in age and likelihood of re-offending is even greater when males and females are examined separately (Perrine, Peck, & Fell,

1989).

Both male and female DWI offenders have similar offending characteristics, such as average age (about 30) and BAC at arrest (.155 for females and .156 for males), but male offenders have a much greater risk of re-arrest than female offenders (Peck, Gebers, Voas, & Romano, 2008). In a DWI recidivism study employing a five-year follow-up time period, one in five females and one in three males re-offended. Male DWI offenders have a higher recidivism rate regardless of number of prior DWI's. There is a large difference, however, between male and female offenders with one prior DWI conviction. In one study, the male re-arrest rate was 25.3, compared to a female rate of 21 (Rauch et al., 2010).

Other predictors of multiple DWI offending are an inclination to engage in risky behavior (e.g., speeding) and impulsivity. DWI offenders who commit more than one offense in a 12-month period have been found to score higher than one-time offenders on scaled items for both of these variables (Nochajski, Wieczorek, & Miller, 1996). Younger persons are more likely than older persons to engage in risky behavior. As a result, there is a 50% greater risk of being involved in an accident for young persons (Ivers, Senserrick, Bougous, Stevenson, Chen, Woodward, & Norton, 2009). Repeat DWI offenders have a greater tendency to engage in sensation-seeking behavior, including impulsivity (Cavaiola et al., 2007). Multiple DWI offenders often experience more depression and seek stimulation, resulting in more impulsive behavior, compared to first-time DWI offenders. Risky behavior and impulsivity are also related to alcoholism, which many repeat offenders have (Shim, Wang, & Bahk, 2015).

There is evidence in the DWI literature that race and ethnicity are related to DWI offending and recidivism (Nochajski & Stasiewicz, 2006). White, non-Hispanics comprise the majority of DWI offenders. Early studies estimated that about 90% of all DWI offenders are white (Morse & Elliott, 1992). More recent studies still find a majority (albeit smaller majority) of white DWI offenders (Sloan, Chepke, & Davis, 2013; VanDyke & Fillmore, 2014; Zettler, Morris, Piquero, & Cardwell, 2015). White, non-Hispanic DWI offenders are also more likely to recidivate nationwide with the exception of the Southwest region where Hispanic and Native American offenders are more likely to recidivate (C'de Baca, Miller, & Lapham, 2001; Chang, Lapham, & Barton, 1996).

Additional predictors of DWI recidivism include risk and needs, employment, social stability, and marital status. A person's criminal risk and need level is used to assign treatment and supervision (Latessa, 2011; Latessa & Lovins, 2010). Higher risk and need levels indicate a greater likelihood of re-offending of any type and a greater need for treatment. General recidivism and DWI-specific recidivism risk and need indicators, although different, do overlap. One commonality of both risk indicators is a person's willingness to change (DeMichele & Lowe, 2011). Socio-personal responsibility is another common risk indicator of general and DWI-specific recidivism, often measured by an offender's self-reported employment (DeMichele & Payne, 2010). Incapacitating corrective methods, such as license suspension or the ignition-interlock device, may affect employment through the limitation of a person's mobility.

Characteristics of social stability, such as employment, dependents, and marital status also affect the probability of DWI recidivism. Employment should reduce

recidivism because it gives an offender something to do, provides an opportunity to pay bills, pay for housing, and widen a person's social network (Petersilia, 2003; Visher & Courtney, 2006). A recent study has found a negative effect of employment on recidivism (Berg & Huebner, 2011; Nochajski & Stasiewicz, 2006). A comparison of recidivist and non-recidivist DWI offenders found that over twice as many of those with prior DWI convictions were unemployed (45%), compared to non-recidivists (Beerman et al., 1988). Studies with 2- and 10-year follow-up time periods, however, have not found significant effects of employment on DWI recidivism (Greenberg, Morral, & Jain, 2005; Pratt, Holsinger, & Latessa, 2000). Interestingly, a majority of DWI offenders are employed, and they are more likely to complete alcohol treatment than those who are not employed (Schell et al., 2006; Saum, Hiller, & Nolan, 2013).

Sampson and Laub (2003) posit that emotional support provided by family members, such as spouses, children, and in-laws, are crucial to desistance from offending. Strong family ties are negatively related to recidivism (Berg & Huebner, 2011). Marital status is an indicator of social stability, and it reduces the likelihood of DWI recidivism. Unmarried DWI offenders complete DWI treatment at a lower rate than their married counterparts (Saum et al., 2013). Those who are not married also experience a significantly higher odds of DWI recidivism (C'de Baca et al., 2001). There is a strong, positive effect of employment on family ties (Berg & Huebner, 2011). Moreover, having an education of 12 years or less results in a greater odds of DWI recidivism, compared to people with more education (C'de Baca et al., 2001).

Offender criminal history, demographic characteristics, and social stability are not just predictors of DWI recidivism; they are also predictors of the imposition of the

ignition-interlock device. Those with prior DWI convictions are more likely to receive the ignition-interlock device because there are many laws requiring multiple offenders to use the device. There are significant differences between those who do and do not receive the ignition-interlock device, leading to bias when comparing these groups. Comparison of matched groups with similar likelihoods of DWI recidivism will eliminate the risk of such bias in estimates of the device's effect on recidivism.

Alcohol-Monitoring Technology

The most widely used alcohol-monitoring technology is the ignition-interlock device. This is designed to prohibit a vehicle from starting if a breath-alcohol concentration test indicates the driver is over a specified limit. The latest generation of ignition-interlock devices was introduced in the 1990s and includes features to increase the reliability of the device, such as hum tone recognition, random rolling retest, 30-day calibrations, and cameras (Elder et al., 2011). The ignition-interlock device is attached to the ignition of a vehicle, requiring the driver to provide an acceptable breath sample before the vehicle will start. The device records the BAC of every test, and a monthly report is provided to the user's monitoring authority. Monitoring authorities that prohibit alcohol consumption may treat breath tests with a BAC over .00 but under the legal limit of .08 as non-compliance with this condition.

The ignition-interlock device is designed to prohibit an intoxicated driver from starting an installed vehicle. Hum tone recognition, random rolling retest, and cameras are features of the ignition-interlock device designed to reduce a user's ability to bypass the device. A hum tone is required every time a breath sample is provided to ensure that a human being is providing the breath sample and not a machine, such as a vacuum or an

air pump. Breath samples are also randomly requested by the device while the vehicle is being driven; this is called a "rolling retest." This feature is used to ensure that the driver who provided the breath sample to start the vehicle is, in fact, the driver of the vehicle. If a rolling retest indicates the driver is over the specified limit, the vehicle may slowly come to a stop, or the horns and headlights may honk and flash until the vehicle is stopped. Most recently, cameras have been attached to ignition-interlock devices to record the individual who is providing the breath sample. Timed with a sample request, drivers are pictured blowing into the ignition-interlock device, and these pictures are reported along with the breath-test results in the monthly calibration report interlock users are required to provide (U.S. Department of Transportation, 2014b).

Alternative alcohol-monitoring devices include portable-alcohol monitors and transdermal alcohol sensors. Portable alcohol-monitors require an operator to provide a breath sample, similar to the interlock; however, these devices are not attached to a vehicle. Commonly, these devices are ordered at a judge's discretion to monitor alcohol consumption of people who are unable to use the ignition-interlock device because they do not have a vehicle. The person is ordered to use the device daily within certain time periods and is required to calibrate the device weekly, bi-weekly, or monthly. These devices have become increasingly popular, but are not ordered as often as the interlock device.

A transdermal alcohol sensor is the most continuous comprehensive alcohol-monitoring device currently used. This device monitors the user 24 hours a day. It comes in the form of a bracelet commonly attached to the ankle, but sometimes on the wrist, that measures the amount of alcohol in the user's perspiration. This device is

ordered to monitor alcohol consumption and is considerably more costly (approximately $12 a day compared to $6 a day for rental and service of the device) to the user. This technology allows for generation of automatic reports to the monitoring authority. Detection of alcohol consumption can be addressed much sooner than is possible with the ignition-interlock or portable alcohol-monitoring devices.

Both of those devices, however, are being equipped with Wi-Fi transmission systems that allow real time or within 24-hour reporting (U.S. Department of Transportation, 2014b). Real time and 24-hour reporting is advantageous because alcohol consumption can be detected much sooner than the conventional ignition-interlock device's monthly test report. This advantage has led to recent advances in the features the ignition-interlock device such as GPS and daily reporting through Wi-Fi transmission. Non-alcohol-monitoring technology, electronic monitoring, and global positioning system (GPS) may also be ordered for DWI offenders but not as often as alcohol-specific monitoring devices. These devices, attached to the offender 24 hours a day, are used to enforce curfew and location restrictions (U.S. Department of Justice, 2011).

There are mixed findings regarding the effectiveness of electronic monitoring or house arrest and transdermal alcohol monitors on DWI recidivism. A 31% reduction in DWI recidivism has been attributed to electronic monitoring (Jones, Wiliszowski, & Lacey, 1996). More recent analysis of an electronic-monitoring mandate on DWI offenders, however, found an 18.8% reduction in DWI recidivism when electronic monitoring was not employed and the ignition-interlock device was used (Roth, Marques, & Voas, 2009). Transdermal alcohol sensors have been identified as effective at

reducing recidivism for DWI offenders with prior convictions. This device has been found to reduce the likelihood of DWI recidivism by 48% for people with at least one prior conviction (Flango & Cheesman, 2009). After device removal, it was found that the time to a subsequent DWI offense was shorter for those with priors during a 40-year follow-up period (Loudenburg, Drube, & Young, 2013). Unfortunately the portable-alcohol monitor is currently under-utilized, and so there are no data on the effectiveness of this device.

This study is concerned with the effects of the ignition-interlock device on recidivism. It excludes the electronic monitoring device, portable alcohol-monitor, and transdermal alcohol-sensors because of a lack of information on these devices, the differences in opportunity to offend among users of these devices, and differences in effects found in prior studies (e.g., Flango & Cheesman, 2009; Roth, Marques, & Voas, 2009; Jones et al., 1996). Furthermore, the ignition-interlock device limits the opportunity for DWI recidivism, and alternative, non-ignition monitoring devices do not.

Pretrial Supervision

Since an increase in pretrial intervention programs in the 1980s, there has been little research on their effectiveness at reducing DWI recidivism. Evaluation of a pretrial supervision program in El Paso, TX found that DWI defendants who received this intervention took significantly longer to re-offend, compared to those who did not, on average about 14 months (Lucker & Osti, 1997). Those receiving the treatment, however, had opted into the pretrial intervention program, indicating a greater motivation to comply. An early pretrial study has also found a 20% reduction in DWI recidivism one year after pretrial intervention for first-time DWI offenders (Fields, 1994). Treatment

for this study, however, was selected by the participants. Using random assignment to pretrial supervision and supervision with services, Austin and Krisberg (1983) found that pretrial supervision had no effect on future offending. In a study of the use of urine tests during the pretrial phase, it was found that those who did not comply with the test schedule were less likely to return to court when compared to those who complied (Visher, 1990).

The most common pretrial method for those charged with DWI is license suspension. This is an administrative punishment used in at least 42 states (Governor's Highway Safety Association, 2014). Similar to ignition-interlock programs, states are provided a funding incentive under the Safe, Accountability, Flexible, Efficient, Transportation Equity Act (SAFETEA) for implementing administrative license policies. The minimum criterion for receipt of this grant incentive is to impose license suspension or a conditional license on those charged with DWI, within 30 days post-arrest, for 90 days to one year (Governor's Highway Safety Association, 2014).

Administrative license suspension has been found to reduce between 5% and 25% of alcohol-related, fatal crashes (Jones & Lacey, 2001; Voas, Tippetts, & Fell, 2000; Blomberg, Preusser, & Ulmer, 1987). Much like the effects of other DWI criminal-justice interventions, the effects of administrative license suspension differ between first-time and repeat offenders. First-time offenders have fewer re-arrests or license violations than offenders with multiple DWI convictions. Those with prior arrests are about 7 times more likely to re-offend or violate their license suspension (Rauch et al., 2010). Administrative license revocation is commonly imposed in conjunction with the ignition-interlock device, or as a condition of license reinstatement. This means that one's license

is invalid unless driving a vehicle installed with the ignition-interlock device.

Pretrial diversion programs are another common method of pretrial supervision. Pretrial diversion, for minor or first-time offenders, seeks to minimize contact between offenders and the criminal justice system. The goal is to provide offenders with the necessary treatment to reduce recidivism (Barton-Bellessa & Hanser, 2012). Diversion programs are more cost effective than incarceration (Camilletti, 2010). These programs commonly mandate treatment, and this has been found to decrease the likelihood of recidivism (Camilletti, 2010). Pretrial diversion programs include a variety of DWI-specific correctional methods, including administrative license suspension and the ignition-interlock device.

To supplement pretrial-service agency supervision, the ignition-interlock device is often imposed on a defendant granted bond. The device is most commonly ordered for people accused of committing alcohol-related driving offenses, such as DWI. It is frequently used because there is little cost to the pretrial-services agency and requires fewer supervision resources than alternative methods, such as electronic monitoring (Byrne & Stowell, 2007). As a result, a large number of defendants accused of alcohol-related offenses have been ordered to use an ignition-interlock device for the duration of their pretrial release.

Probation Supervision

Another integral phase in the post-arrest process is probation supervision. This is of primary importance to this study because a large number of people convicted of DWI are given this sentence. In 2013, 14% of all probationers were DWI offenders. This offense type is second only to broader offending categories, such as property and drug

offenses (Herberman & Bonczar, 2014). A greater understanding of the effects of the ignition-interlock device on DWI recidivism will inform how long a punishment the court should impose for maximum effectiveness, and in what post-arrest phase the ignition-interlock device should be imposed for the best chance of reducing recidivism.

Although there is a greater body of literature regarding the effects of probation than the effects of pretrial supervision, the effects of probation supervision are debated. Much of the probation literature is either inconclusive or has identified moderate, negative effects on recidivism after sentence completion (Pearson, McDougall, Kanaan, Bowles, & Torgerson, 2011; MacKenzie, 2000; Sherman, Farrington, Welsh, & MacKenzie, 2002). It is argued that probation may be effective in reducing DWI recidivism, but it is difficult to identify what about this criminal justice intervention is effective because it varies so much among agencies (McDougall, Perry, & Farrington, 2006).

The influence of probation supervision on DWI recidivism is better understood. An early meta-analysis of over 217 studies concerned with the effects of probation on recidivism has found a seven to nine percent decrease in drunk-driving recidivism (Wells-Parker, Bangert-Drowns, McMillen & Williams, 1995). A more recent meta-analysis of studies since 1995 indicates that DWI intervention methods reduce recidivism, especially if several intervention methods are used together (Miller et al., 2015).

A common feature of many probation studies is selectivity bias. This bias is present for the simple fact that those serving probation are likely to be the "best" offenders (Pearson et al., 2011). Examination of the "best" offenders, those who are least

likely to re-offend, becomes problematic when they are compared to "worse" offenders. Experimental design is the best approach to addressing this issue of selection bias. Of the 97 studies examined in the more recent meta-analysis, only two met the Maryland Scale of Scientific Rigor's five-point criteria (Miller et al., 2015). This five-point rating is given to studies that employ an experimental design. One of these studies examines the effects of interlock-probation programs and the other of educational-probation programs on DWI recidivism. The ignition-interlock study reported that participation results in a 36% reduction in the likelihood of recidivism and a 26% reduction after removal of the device (Rauch, Ahlin, Zador, Howard, & Duncan, 2011). Participation in education programs reduced recidivism for the first nine months after probation sentence, but this effect later dissipated (Ekeh, Hamilton, D'Souza, Everrett, & McCarthy, 2011).

Pretrial and Probation Supervision

To date, there has not been a study of the effects of condition imposition over both pretrial and probation supervision post-arrest phases on recidivism. The increased formality of the pretrial-release process and the current trend of evidence-based practices in probation supervision call for examination of these combined corrective measures. Both pretrial and probation agencies employ similar corrective approaches encouraging deterrent, incapacitating, or rehabilitative methods. Existing literature, however, has primarily focused only on probation supervision's effects on recidivism.

The goals of pretrial and probation supervision are also arguably similar. Pretrial-services agencies work to increase the likelihood of a defendant's return to court and prevent a re-arrest while on pretrial release. These pretrial goals mimic the goals of probation to increase the likelihood that an offender's probation sentence is successfully

completed, and the offender does not re-offend while under probation supervision, and after supervision is complete.

It is important to consider the influence of both pretrial and probation supervision efforts on recidivism because they are likely to be perceived by offenders as similar. The most similar goal is to increase the likelihood that offenders under supervision will not be arrested for a subsequent offense. Also similar are the goals to increase the likelihood that an offender will comply with the bond condition or the successful completion of the probation sentence. Pretrial measures to increase the likelihood of an offender's return to court commonly involve court-date reminders at pretrial-supervision office visits and/or reminder phone calls. Similarly, probation supervision efforts to successfully execute an offender's probation sentence also often involve reminders to complete the conditions of probation during office visits and/or phone-call reminders about completion of technical conditions.

Ignition-Interlock Device and Recidivism

Alcohol-monitoring technology is a commonly used tool for reducing DWI recidivism. It may be ordered for different reasons. The primary goal for the device's use, however, is to incapacitate and possibly deter a person from driving while intoxicated. The extant research on the effects of alcohol-monitoring technology on DWI recidivism has focused on the ignition-interlock device. This may be attributed to the longer time period this device has been used and/or the popularity of this device across jurisdictions (McCartt et al., 2012).

Overwhelmingly, studies of the effects of alcohol-monitoring technology, specifically the ignition-interlock device, have found no significant differences between

the likelihood of recidivism for those who use the ignition-interlock device and those who do not, after the device is removed (EMT Group, 1990; Voas, Blackman, Tippetts, & Marques, 2002; Morse & Elliot, 1992; Raub, Lucke, & Wark, 2003; Roth et al., 2005; Voas, Blackman, Tippetts, & Marques, 2002). The existing DWI-recidivism literature reveals an average risk reduction of 18%-64% while the device is installed (Elder et al., 2011; Willis, Lybrand & Bellamy, 2004).

There have been two notable ignition-interlock studies using random assignment in the last 15 years. However, the random assignment in both of these studies did have some procedural limitations. Participants were given the opportunity to select into treatment and install the ignition-interlock device or continue with a suspended license. This resulted in a large portion of each sample electing to not use the device (Beck et al., 1999; Rauch et al., 2010). Beck et al.'s (1999) study, employing a two-year follow-up period, one-year installed with the device and one-year after device removal, found no significant difference between those with and without the device. They, however, identified a 32% average reduction in recidivism over the full, installed and uninstalled, follow-up time period. Rauch et al.'s (2010) randomized study of the effects of the ignition-interlock device on recidivism revealed a reduction for users of 26%, two-years following device removal. A 7.4% reduction during the first year of interlock installation was found to level out completely within three years of after removal (Raub et al., 2003).

Event history analyses of the ignition-interlock device have also found a difference in its effects after removal. First-time offenders had a 61% lower hazard of re-offending while installed, but only an 18% lower hazard after removal (Roth et al., 2005). Studies with longer follow-up time periods have found an even greater leveling out of the

interlock's effect. In a four-year follow-up study, interlock users had a higher rate of recidivism than those who did not use it by the end of the study time period. The annual rate of recidivism decreased for repeat offenders about 10% (Rauch et al., 2002).

This degenerating effect of the ignition-interlock device may indicate that there is no incapacitating effect on users but rather a deterrent effect. This delayed reversion to drinking and driving has also been defined as an educative effect. Analysis of ignition-interlock device user's biomarkers of alcohol consumption and driving patterns, while installed and after device removal, has shown that individuals will change their driving behavior while remaining a problem drinker (Marques et al., 2010; Marques & Voas, 2012). Both deterrent and educative effects of the ignition-interlock device result in a reduction of drinking and driving, but require different measures to be estimated. Information pertaining to participant's alcohol consumption beyond arrest for DWI was not available so this study is limited to inference about the possible deterrent effects of the device.

Some research has shown that ignition-interlock devices affect first-time and repeat DWI offenders differently (Coben & Larkin, 1999; Elder et al., 2011; McCartt et al., 2012; Voas & DeYoung, 2002). This difference may be attributable to a difference in the likelihood of DWI recidivism across these offender groups. A reduction in recidivism while the ignition-interlock device is installed has been found for both offender groups, although the impact differs (Roth et al., 2005). In one matched-sample comparison, the overall reduction in recidivism risk for interlock users was 32%, compared to a 41% reduction for repeat DWI offenders (DeYoung, Tashima, & Masten, 2005). The survival rate of not re-offending for both first- and repeat-offenders after device removal is higher

for first-time offenders. About 94% of first-time offenders are likely to not re-offend within two-years after device removal, compared to 88% of repeat offenders (Marques et al., 2003).

The current literature pertaining to the ignition-interlock device and DWI, although extensive, has neglected to examine how use of this technology during post-arrest phases, especially pretrial, may affect the likelihood of recidivism. Little is known about the effects of pretrial-supervision on the likelihood to re-offend after case disposition or sentence completion. The difference found in the effects of post-arrest supervision on recidivism indicates that more robust methods are needed. Furthermore, the lack of consistent measures of recidivism in criminal justice research indicates a need for examination of varying follow-up time periods and recidivism measures.

Existing literature examines how pretrial supervision affects the likelihood of re-arrest during pretrial release and the effects of probation supervision on subsequent offending after sentence termination. It, however, fails to include the effects of combined treatment during both phases. The similarity in pretrial- and probation-supervisory methods justifies further examination of their joint effects.

This study addresses these gaps in the literature by using robust matching techniques to construct similar treatment and comparison groups. This addresses the selection bias for those ordered to use the ignition-interlock device by reducing the potential influence of unobserved covariates on the outcome variable. Most studies of the ignition-interlock device focus on either the time period the device is installed or the time period after the device has been removed. This allows for an inference to be made about either an incapacitation or deterrent effect. This study is different from previous studies,

in that it uses a long-term and a short-term follow-up period to examine while the device is installed and after device removal. The long-term period spans from each offender's installation-order date to the end of the data collection period, and the short-term follow-up period that spans 12 months, regardless of sentence termination date.

III. RESEARCH QUESTIONS AND HYPOTHESES

To conduct a comprehensive study of the effects of the ignition-interlock device on recidivism, both pretrial and probation, the research questions focus on the likelihood of re-offending, timing to re-offense, and compliance with conditions of probation sentence. The effects of pretrial supervision are largely unknown. What is known about probation's effects is limited by methodological problems, and the effects of combined pretrial and probation supervision have yet to be examined. To fill these gaps in the literature, this study inquires about the ignition-interlock device's effects. The results provide insight into the incapacitating and possible deterrent effects of the ignition-interlock device.

Research question 1: Does the ignition-interlock device reduce a DWI offender's likelihood to commit a subsequent DWI?

1a. Does the ignition-interlock device reduce a DWI offender's likelihood to commit a subsequent DWI when imposed during the pretrial phase?

1b. Does the ignition-interlock device reduce a DWI offender's likelihood to commit a subsequent DWI when imposed during the probation phase?

1c. Does the ignition-interlock device reduce a DWI offender's likelihood to commit a subsequent DWI when imposed during both the pretrial and probation phases?

Hypothesis 1: The ignition-interlock device decreases a DWI offender's likelihood to re-offend.

1a. Those receiving the interlock treatment during the pretrial phase will have a lower likelihood of DWI recidivism than those who do not.

1b. Those receiving the interlock treatment during the probation phase will have a lower likelihood of DWI recidivism than those who do not.

1c. Those receiving the interlock treatment during both the pretrial and probation phases will have a lower likelihood of DWI recidivism than those who do not.

The degenerating effect of the ignition-interlock device after it is removed introduces time as an element in the analysis. To examine this time-dependent effect, this study examines the difference in average time between the treatment and an occurrence of DWI recidivism. In a matched comparison study, Morse and Elliott (1992) identified a lower survival probability for interlock users spanning 30 months. The following, time-dependent research questions provide greater insight into a potential deterrent or incapacitating effect.

Research question 2: Does the imposition of the ignition-interlock device reduce the time when a DWI offender is likely to re-offend?

2a. Does the imposition of the ignition-interlock device imposed during the pretrial phase result in a longer time to a subsequent DWI?

2b. Does the imposition of the ignition-interlock device imposed during the probation phase result in a longer time to a subsequent DWI?

2c. Does the imposition of the ignition-interlock device during both pretrial and probation phases lengthen the time to a subsequent DWI?

Hypothesis 2: The ignition-interlock device increases the length of the time that a DWI offender will re-offend.

2a. Those who use the ignition-interlock device during the pretrial phase will take

longer to commit a subsequent DWI than those who do not.

2b. Those who use the ignition-interlock device during the probation phase will take longer to commit a subsequent DWI than those who do not.

2c. Those who use the ignition-interlock device during both the pretrial and probation phases will take longer to commit a subsequent DWI than those who do not.

Inquiry into the ignition-interlock device's effects on types of re-offending other than DWI is also made to evaluate the device's effects on non-alcohol related criminality. A significant effect of the ignition-interlock device on the occurrence of or time to non-alcohol related recidivism indicates the device reduces the likelihood of criminal behavior beyond problem drinking and driving. This series of research questions pertains to all non-DWI offenses referred to as "non-alcohol recidivism."

Research question 3: Does use of the ignition-interlock device affect non-alcohol recidivism?

3a. Does the ignition-interlock device reduce the likelihood of non-alcohol recidivism?

3b. Does the ignition-interlock device lengthen the time to non-alcohol recidivism?

Hypothesis 3: The ignition-interlock device affects non-alcohol recidivism.

3a. Those who use the ignition-interlock device will have a lower likelihood of non-alcohol recidivism.

3b. Those who use the ignition-interlock device will take longer to commit a

subsequent, non-alcohol related offense.

To provide a comprehensive examination of the ignition-interlock's effects, there must also be inquiry about the effects of the device and probation compliance. It is important to identify whether the ignition-interlock device has a significant effect on compliance with all probation conditions.

Research question 4: Does imposition of the ignition-interlock device increase a DWI offender's likelihood of compliance with probation conditions?

4a. Does the ignition-interlock device increase the likelihood of a DWI offender committing administrative, non-compliance or other violations while on probation?

Hypothesis 4: Use of the ignition-interlock device increases a DWI offender's likelihood to comply with conditions of probation.

4a. Those who use the ignition-interlock device during the probation phase will have more non-compliance with technical-probation conditions than those who did not use the ignition-interlock device during this phase.

A methodological inquiry about the differences in how to control for selection bias is also made. Previous studies of pretrial and probation supervision have been criticized as employing poor methodology, introducing a need for greater understanding of techniques for reducing selection bias. To explore possible differences in outcome, robust matching techniques are compared to a multivariate logistic regression analysis.

Previous studies comparing propensity score matching to conventional multivariate control techniques have produced mixed findings. In a review of 56 studies using both techniques, Sturmer, Joshi, Glynn, Avorn, Rothman, and Schneeweiss (2006) found a less than 20% difference between effect sizes produced by the two types of analysis. A comparison of propensity score matching and a multivariate regression analysis by Cook and Goldman (1989) revealed no statistically significant differences in statistical significance across results. The differences, however, in means across the treatment and comparison group's confounding variables were large (Cook & Goldman, 1989). Drake's (1993) comparison of these techniques indicates no difference in results, but found a potential for significant differences when either matching or multivariate model were mis-specified.

Alternatively, Kurth et al.'s (2005) comparison of a multivariate regression analysis and propensity score matching, applied to two samples, found similar odds ratios. In an examination of a tissue treatment's effects on stroke patients' risk of death, a multivariate regression analysis produced an odds ratio of 1.93 compared to the matched sample's odds ratio of 1.17. Another study found similar results, indicating that the number of events per confounding variable plays a role in the amount of bias present in the results produced by both techniques. It was found that the stronger the association between the confounding variables and the receipt of treatment, the more bias was present in the regression results; however, the matched sample results remained unaffected (Cepeda, Boston, Farrar, & Strom, 2003).

Building on previous research, this study compares the results from these techniques using equivalent samples. Furthermore, a direct comparison is made between

these techniques controlling for the differences across the same confounding variables.

Research question 5: Does matching according to characteristics relevant to the imposition of the ignition-interlock device produce different effects than a multivariate regression analysis that seeks to statistically control for selection bias?

Hypothesis 5: Use of a matching technique to construct similar comparison and experimental groups will produce effects different in magnitude than effects produced using a multivariate regression analysis approach that controls for selection bias.

The conceptual model that is used to test the hypotheses is represented in Figure 1.

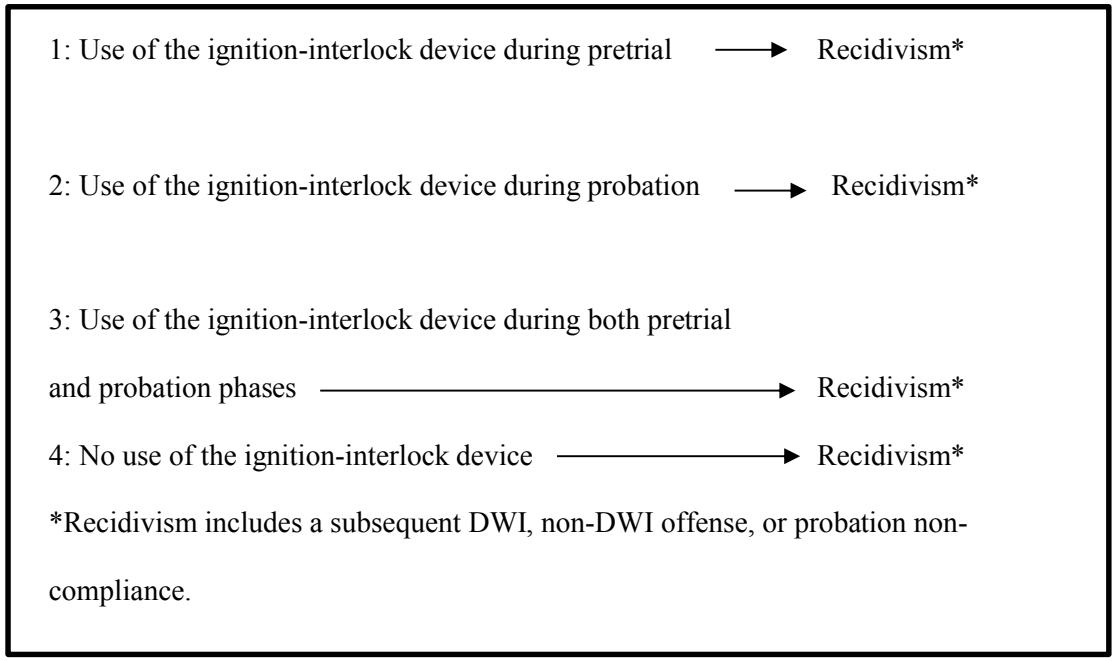

Figure 1. Conceptual Model

Models 1 and 2 (Figure 1) address the effects of the ignition-interlock device during pretrial or probation on recidivism, including the occurrence of, and the time to recidivism. Model 3 will be used when these same effects are examined for those who used the ignition-interlock device during both, pretrial and probation phases. Model 4

represents a recidivism outcome absent use of the ignition-interlock device. This will serve as a comparison to models 1, 2, and 3 (Figure 1).

IV. METHODS

The methods described in this chapter are used to assess the effects of the ignition-interlock device as outlined in the research questions. The description of the data collected and processed is provided along with an explanation of the variables included in the matching procedure and analyses. Finally, there is a discussion of the matching procedure used to construct each treatment sample and the post-matching analyses used to assess the interlock device's effects.

Sample

The sample includes people arrested for DWI between February, 2007 and October, 2010 in Travis County, TX and subsequently convicted of a DWI or alcohol-related charge and sentenced to probation in Travis County, TX. Related charges include reckless driving or obstruction of a highway. The sample excludes individuals arrested and convicted in Travis County, TX who served their probation sentence in another jurisdiction. These people are excluded because information pertaining to their compliance while on probation was unavailable. The sample totals 6,613 people before the matching procedure. After matching, the sample size decreases because unmatched cases are eliminated from the sample.

The follow-up time period to measure recidivism begins when the order to install the ignition-interlock device is made until the end of one year after device removal or the follow-up time period (April, 2015). This provides for a range of time periods from 30-days to 92-months, including pretrial release period, probation sentence, and after sentence termination. The treatment and comparison groups are defined by the imposition of the ignition-interlock device during pretrial or probation. People ordered to

use this device during pretrial release, probation sentence, or during both are included in the treatment group, and those never ordered to have the device are the comparison group (see Figure 1 in Chapter 3). Those cases in either group that are successfully matched remain in the sample for post-matching analyses. Information confirming installation was only available for those ordered to have the ignition-interlock device during the pretrial phase not those ordered during the probation phase. Failure to install the ignition-interlock device during the probation time period most commonly results in a revocation of probation.

Data

The data come from two data sources and three datasets. Data were obtained from Travis County Community Services and Corrections Department (CSCD) and the Texas Department of Public Safety (DPS). Travis County CSCD includes both pretrial services and adult probation supervision in Travis County, TX. Texas DPS is the statewide agency responsible for overseeing highway safety and licensing. Texas DPS is also responsible for maintaining criminal record information reported by all law enforcement agencies in the state.

The Travis County CSCD data contain information pertaining to pretrial release and probation sentence. Pretrial release information includes both type of bond release and the conditions ordered at pretrial release (see Appendix A). This dataset is derived from an electronic database (Tiburon, Inc.), managed by Travis County Pretrial Services. This information system is accessed by pretrial services officers, and information is entered at the time of pretrial release. Commonly, this release occurs within 24 to 48 hours of the initial arrest.

The probation data from Travis County CSCD include offender demographic variables, offense information, supervision level, risk assessment at intake and re-assessment at six months, compliance information, and conditions ordered (see Appendix A). The probation dataset is derived from a database managed by Corrective Software Solutions. Offender information is initially input by an intake officer during the initial intake office visit. Following this initial visit, information pertaining to the probationer is entered primarily by the probation officer. This information is current as of the last contact the probation officer had with the offender.

The third dataset comes from the Texas DPS and includes public, criminal history records for all individuals included in the sample. This information reports all arrests and their outcomes for adult offenders, age 17 or older. Those data include offenses committed, date of the offenses, arresting agencies, case dispositions, and sentences (see Appendix A). The dataset for the criminal history information is managed by law enforcement agencies in Texas. Information pertaining to an offender's arrest and subsequent case dispositions are entered by trained law enforcement and court officials. This dataset is assumed to be current to the termination of the follow-up time period, April, 2015 and includes all class B or greater offenses, such as reckless driving or obstruction of a highway, but excluding traffic offenses.

To construct the comprehensive dataset for the matching procedure, the three datasets were merged together. These datasets were merged, using state identifying number (SID's). This number is assigned at the time of a person's first arrest and is a unique identifier that is used to reference a person's criminal history for any subsequent arrest. The pretrial release information contained all individuals arrested in Travis

County, Texas for DWI from February, 2007 to October, 2010. This included 34,985 incidents processed through the Travis County Jail for a charge of DWI. Of those 34,985 incidents 13,346 were incidents for a new DWI offense and the remainder for warrants for older offenses. Of this larger group of new DWI arrests, 6,616 were subsequently convicted and served probation in Travis County (Table 1). The excluded cases were individuals who were either not convicted, or convicted but did not serve their probation sentence within Travis County. How many of the excluded cases resulted in a conviction or not was unknown.

Table 1. Cases Excluded and Included in Comprehensive Sample

Total incidents of DWI arrest February, 2007 to October, 2010	13,346
Excluded: -Not Convicted -Convicted and Sentence to Jail or Prison -Convicted and Transferred to outside Travis County	6,730
Included: -Convicted and Sentence to Probation in Travis County	6,616

This merge of the datasets from pretrial and probation resulted in a loss of 13 cases (.19% of the total sample) because a person's matching SID was not located in either dataset. Because the SID is a unique identifying number and never duplicated, this loss of cases is likely attributable to random entry error. Once these datasets were successfully merged, the data from the Texas DPS were then merged, using the offenders' SIDs. No cases were lost in this merge so the sample size of the final comprehensive sample is 6,613. This dataset included all variables from the three datasets, and each case contained information on individual pretrial, probation, and criminal histories.

Data Management

The missing data in all three datasets were assessed for non-randomness. If any

non-randomness was identified the missing values would have been treated with imputation. Imputation is simply replacing missing values with values that would be most likely based on the characteristics of the sample (Schafer, 1999). Proper imputation of missing data increases sample size, while preserving relationships between observed variables (Rubin, 1976). Furthermore, confounding variables must be void of missing data to be included in propensity score matching procedures (Holmes, 2014). Multiple imputation is performed to account for missing data if any trends are found in the missing data. This process involves modeling the variation in a variable to predict the missing values using unobserved random data of any variable that will be included in the analysis (Holmes, 2014).

Data Description

The data used in this study contain a large amount of information about individuals and their probation sentence compliance. Information pertaining to the individual offender is important because individual characteristics will likely be identified as confounding variables to DWI recidivism. These variables are crucial to performing the matching procedure and ultimately constructing similar treatment and comparison groups. The large amount of information pertaining to sentence compliance is useful for this study because it allows for examination of recidivism, as well as, probation non-compliance. Furthermore, the information about type of non-compliance allows for examination of the difference between the ignition-interlock device's effects on legal and non-legal behavior.

Outcome Variables

The effects of imposition of the ignition-interlock device on offending are

measured by the occurrence of recidivism, measured by arrest for any alcohol-related crime, including – a DWI offense, intoxication assault, and intoxication manslaughter. Non-alcohol recidivism is measured by arrest for any other non-alcohol related crime. Technical violations will also be measured as an outcome variable. Technical violations during probation include behavior outside of the conditions of probation, but not unlawful. This can include administrative non-compliance, such as failure to pay fees, failure to participate in treatment, or failure to appear to office visits. It also can include condition non-compliance, such as positive drug and alcohol urinalysis, and any other type of non-compliance (see Appendix A).

Technical violations do not include violations of the ignition-interlock device. Although this is a technical violation this information was not included in the data for this study. This means that inference from analysis of the ignition-interlock device's effect on the probation non-compliance can only be made to the other probation violations outside the use of the ignition-interlock device.

Arrest is more appropriate than conviction for measuring recidivism because arrest introduces less error to the outcome variable. Recidivism can be either an arrest that does or does not result in a conviction. The difference between arrest and conviction presents researchers with a choice between errors of omission and errors of commission. An error of omission occurs when false *convictions* of factually guilty individuals who are not legally convicted or plea bargain to a lesser charge and counted as non-recidivism, and errors of commission occur when false *arrests* of the factually innocent are counted as recidivism (Blumstein & Cohen, 1979). Debate over the two types of errors should be decided on how they will affect the accuracy of the recidivism measure.

An error in commission is identifying an event as a non-event such as the case in arresting an innocent person. However, an error in omission is failing to properly identify an event that has occurred, such as factually guilty offenders being found innocent. This error of omitting factually guilty offenders is a more serious issue for predicting recidivism. The legal process provides opportunities, such as diversion programs or dismissal because of due process, for an error in omission to occur making conviction a problematic recidivism measure (Blumstein & Cohen, 1979). Approximately 17% of DWI offenders involved in crashes are arrested and convicted, leaving 11% arrested and not convicted, and 72% never arrested or convicted (U.S. Department of Transportation, 2002).

In addition to assessing the ignition-interlock device's effects while installed, two follow-up time periods after the device is removed are used, ranging from 12-92 months. This length of this total observation time period justifies use of two time periods to measure the outcome variable, one that is static, short-term and one that is dynamic, long-term. The time period consistent across all cases is 12 months, and the follow-up period that varies for all cases extends to April, 2015, when the data were received. The 12-month follow-up period provides for ample time to examine a DWI offender's short-term likelihood of re-offending and up to 92 months to examine long-term recidivism.

Those who refuse to provide a blood or breath sample and have a prior DWI conviction are eligible for a license suspension of up to two years if they do not install the ignition-interlock device (Tex. Administrative Code § 17.11, 2008). The comparison groups for each treatment are likely to maintain different license suspension status. This is a result of the two-year license suspension many DWI offenders receive that restricts

them from driving a vehicle not installed with the ignition-interlock device. This means that an individual in the comparison group may have a suspended license up to two years after their DWI arrest. The greatest consequence is to the measurement of the treatment effect while the ignition-interlock device is installed, pre-conviction, because it is likely that is when the license suspension will occur. The average trial time in the sample is 330 days so, on average, the duration of the installation period for the pretrial and combined pretrial and probation time periods, the comparison group will also be restricted in their opportunity to commit a subsequent DWI.

The matching procedure will account for a portion of this difference in comparison the group because the decision to assigned administrative license suspension relies on similar factors as the imposition of the ignition-interlock device. Furthermore, the short-term and long-term follow-up time periods are less likely to include comparison cases that are experiencing this license restriction because, on average, occur over two years from the DWI arrest. This lack of information on license suspension is a limitation of this study because it may result in skewed estimates. Without the license suspension restriction those without the ignition-interlock device would have a greater opportunity to commit driving related offenses. This means the difference in the comparison group may lead to an under-estimation of the treatment's effects.

The long-term follow-up time period exceeds this suspension time period, and allows for examination of the effects of the ignition-interlock device with and without administrative license suspension. The longer recidivism time period is advantageous not only because it spans beyond the maximum license-suspension time period, but it also provides more information about the changes in the ignition-interlock's effects over time.

A majority of studies about the device's effectiveness, on average, use a two-year follow-up (Miller et al., 2015), compared to this study's long-term follow-up of up to six years.

The data for this study are right-censored. Censoring is an important element when examining a specific time-to-failure event. Persons in the sample who recidivate after the end of the follow-up period are identified as those who did not fail because of this censoring characteristic. Censoring can possibly introduce Type I errors because of the potential for misidentification of those who fail after the end of the time period. Large samples are more likely to provide results more consistent with non-censored data (Lagakos, 1979). Survival analysis, which is used in this study, is considered to be an appropriate method when using censored data. This analysis provides two, time-related outcomes, the time to the event which is recidivism, and the event status at the end of the follow-up time period, which is no recidivism (Cox & Oakes, 1984).

The different placement of the ignition-interlock treatment in the time period results in different time periods for each treatment group. All of the time-dependent information is censored in the same manner. Practically, the data used for this analysis do not allow for observation over each person's lifetime, so the information is right-censored at the final date of data collection, April 22, 2015. The limitation of this censoring approach is that the occurrence of recidivism after the censored date is not observed as a recidivism event for the outcome variable (Allison, 1984).

The right-censoring of the time-dependent data is non-informative and either singly censored or randomly censored. The singly censored data have one set end date to the observation time-period. For example, the short-term time period, which is singly, right-censored, ends for all persons in the sample in one year (364 days). Alternatively,

the random-censored data have person specific end dates, dependent on when the arrest and sentence termination fall within the total observation time-period. The long-term time period that expires the final date of data collection is random, right-censored because the censored period is predetermined by the study's data-collection parameters.

Although use of censored data is not ideal for time-dependent analysis, the short-term and long-term time periods censoring is non-informative, which will not influence the presumed hazard or survival time to an observed event. The actual time to the recidivism event is unrelated to either the singly or random-censored information because each entry into the sample, as a result of a DWI arrest, is random over the predetermined observation time period. This meets the non-informative, censoring assumption that is necessary for proportional hazard and time-to-event analysis. The time-dependent analyses include the time of entry into the study time period in order to account for any biases that may be present because of censored information (Allison, 1984).

Independent Variables

The independent variable in this study is the imposition of the ignition-interlock device. This study's intent-to-treat perspective distinguishes between whether or not treatment was ordered and/or installed. Pretrial interlock treatment is defined by the date of installation and probation interlock treatment by date the device is ordered by the court. Ideally, the probation treatment would also be defined by the date of installation, but this information was not available. DWI offenders are not likely to select into an ignition-interlock program. In some states the percentage of DWI offenders who do select in are as low as 1% to 4% (Tippetts & Voas, 1998; Simpson, Mayhew & Beirness, 1996). Similar to the reluctance to select into an interlock program, some may get the

order, but never install. Not having information that confirms the ignition-interlock device was installed during the probation time period may lead to those who never installed the device as receiving the treatment. It is assumed that offenders are likely to see the order and installation of the device as roughly the same and alter their behavior accordingly. Ultimately, this shortcoming can result in a false negative were individuals who never installed the device and re-offending are included in the treatment group.

The intent-to-treat perspective captures the occurrence of recidivism and probation violations from the offender's first opportunity to commit them, upon order of the device. Although this will neglect differences in the administration of the treatment, it will measure its effects on the outcome variable (Maltz, 1984). The treatment will be categorized according to imposition of the ignition-interlock device at different post-arrest phases. It will be coded dichotomously as order imposed (Yes or No). Treatments will be divided into four types: (1) order and installation of the ignition-interlock device during the pretrial phase, (2) ordered during the probation sentence, (3) during both installed during pretrial and ordered at probation, and (4) not installed or ordered during either phase.

There were a total of 6,613 total cases in the comprehensive dataset. From this dataset an additional 1,550 cases were eliminated from the sample because they did not fit the sample criteria. Of these eliminated cases, 1,224 were removed because the probation term had not been completed at the time of data collection, and 326 were removed because those people were already on probation at the time of the DWI arrest that entered the person into the study. The final sample contained 5,063 cases from which 156 individuals had installed the ignition-interlock device during the pretrial post-

arrest phase, 642 were ordered to install during probation, 187 both installed during pretrial and were ordered to install during probation, and 4,078 did not install or receive an ignition-interlock installation order during any post-arrest phase. This sample provided enough cases to perform the matching procedure because it was large, and the majority of the cases did not receive the treatment, allowing for more opportunities to identify appropriate treatment and comparison case matches.

Matching Variables

Similar treatment and comparison groups were constructed by propensity score matching. The sample was truncated according to specific characteristics that could influence the imposition of the ignition-interlock device. Cases were matched according to these characteristics, and those that did not match across treatment and comparison groups were removed from the sample. Ideal matching variables affect both the participation decision and the outcome variable (Heckman, Ichimura, & Todd, 1997). For this reason, matching variables were selected that have been empirically linked to the assignment of the ignition-interlock device and the likelihood of DWI recidivism.

Morse and Elliott (1992) used a cluster analysis to match treatment and comparison groups according to self-classification of problem drinking, number of prior alcohol- and other-drug related offenses (non-DWI), and number of prior DWI arrests. The initial matching variables selected for this study were derived from Morse and Elliott's (1992) study, as well as, from existing literature identifying predictors of DWI recidivism. The matching procedure was exploratory because not all variables proposed for the matching were ultimately used to construct the two groups.

Four categories of matching variables have been identified: offender demographic variables, criminal risk and need level, criminal history, and conditions of release (see Appendix B). These categories of variables are most relevant to the matching procedure because they contain predictors of DWI recidivism identified in the existing literature. Those ordered to install the ignition-interlock device to reduce the risk of DWI recidivism are likely to be older, have higher incomes, have more prior offenses, or more serious prior offenses (Elder et al., 2011). Furthermore, repeat DWI offenders, who are more likely to have the ignition-interlock device ordered during pretrial release or probation sentence, are more likely to be single and Hispanic (C'de Baca et al., 2001). This justifies matching for offender demographic variables, such as age, gender, race, ethnicity, sex, marital status, number of dependents, and employment status.

The relationship between criminal risk/need level and non-alcohol recidivism in the existing literature justifies inclusion of total risk and need scores in the matching procedure. Furthermore, these scores are used by judges as a guide for condition assignment. Risk/need characteristics include total risk and need assessment scores and individual indicators of risk and need that make up the assessment scores (see Appendix B). The scores used in this study are generated from the Ohio Risk Assessment Tool (ORAS), which is commonly used in probation settings. This risk assessment tool is designed to capture the risk and need factors of people sentenced to probation for the purpose of effective classification to programs and treatment. (Latessa, Lemke, Makarios, & Smith 2009a). Validation of this tool has shown risk assessment has a ($r = .37$) correlation with recidivism (Latessa, Smith, Lemke, Makarios, & Lowenkamp, 2009b). The ORAS is used twice during a probationer's probation sentence, once at intake and six

months after intake to measure any changes in risk or needs. Static risk and need indicators are more consistently measured across individuals than are dynamic characteristics (Vera Institute of Justice, 2011). The initial risk assessment scores and risk/needs indicators are used for the matching procedure because they best represent an offender's likelihood of imposition of the ignition-interlock device under an intent-to-treat perspective.

A DWI recidivism-specific risk and needs scale is preferred because the process of DWI recidivism may differ from the process of general recidivism, leading to different risk and need indicators (DeMichele & Payne, 2010). Although these indicators differ, they are not mutually exclusive, and there is a significant amount of overlap between these scales. DWI recidivism-specific scales should contain substance abuse, risky behavior, and lack of respect for the law items under such domains as mental health, socio-personal responsibility, risky substance use, criminal history, desire for change, internalized locust of responsibility, and risky driving (DeMichele & Lowe, 2011).

The Ohio Risk Assessment System (ORAS) is a general criminal recidivism assessment that measures these DWI risk indicators. Adhering to the risk, needs, and responsivity principles (Latessa & Lovins, 2010), the ORAS contains measures consistent with DWI recidivism risk and need indicators, such as mental and emotional problems, isolation from prosocial people, problem with drugs or alcohol, prior criminal history, temperament and personality (including impulsivity and adventurous), and attitude toward change (Latessa & Lovins, 2010).

Risk and need are also ideal matching variables because they serve to balance the order of probation conditions. Assessment scores are used to inform criminal justice

officials' decisions to order probation conditions. In combination with ignition-interlock treatment, DWI offenders are likely to receive additional conditions, such as community service hours or participation in treatment programs. Because probation conditions are assigned according to risk and need scores, matching across these variables minimizes the differences in the treatment and comparison group's probation conditions.

An offender's criminal history is measured by prior felony arrests, as well as, the number of prior DWI's. Those with prior DWI's or lengthy criminal histories maintain a higher risk of future DWI offending (DeMichele & Payne, 2010). Imposition of the ignition-interlock device relies on the perceived risk of re-offending, legal requirements according to charge level, and offense severity. Conditions of bond release, including alcohol treatment, supervision, type of bond and personal bond release, are included in the matching procedure (see Appendix B). The imposition of alcohol treatment and supervision are related to the likelihood of receiving an ignition-interlock device because they are conditions used in conjunction with the ignition-interlock device to reduce the risk of recidivism. The risk of non-compliance when released on a financial bond differs from the risk when released on one's own recognizance. This ultimately relates to the likelihood to recidivate, so its influence is taken into account in the matching procedure.

Matching Procedure

Propensity score matching was used to construct the treatment and comparison groups. This matching procedure seeks to remove selection bias in order to allow for the identification of causal effects in observational studies (Guo & Fraser, 2009). Selectivity includes both the observed and hidden selections that can be eliminated through random assignment (Heckman, 1976). The lack of randomization in observational studies

introduces selection bias that can affect the observed outcome. This means that influences on the outcome that are not present in the model will be misrepresented by other variables. Absent the opportunity for random assignment, observational studies may be improved by comparison of matched treatment and comparison groups.

Propensity score matching has supporters and critics. Dehejia and Wahba (1999, 2002) evaluated this technique by replicating experimental data, finding very few biases due to the matching technique. Critics question the generalizability of these samples across time and geographic location, whether bias occurs when there are not enough matching variables, and whether a total balance across groups, found in experimental design, is actually possible (Smith & Todd, 2001; Smith & Todd, 2005). In response to these criticisms, Dehejia (2005) advises that only covariates of interest must be balanced for adequate control of confounding variables, and generalizability of matched samples can only be made to those also likely to receive the specific treatment.

Both sides ultimately agree that defensible propensity score matching must include all of the variables established in prior research to be relevant to the imposition of treatment and outcome, include a sensitivity analysis of the model, and that the non-experimental comparison group originate from the same group of participants as the treatment group (Dehejia, 2005; Smith & Todd, 2001; Smith & Todd, 2005). The breadth of matching variables in the present study provides ample matching variables related to both treatment and outcome, and treatment participants originate from the same sample of DWI offenders arrested during the same time period and within the same jurisdiction.

The National Institute of Justice and the Cochran Collaboration recommend

propensity score matching in the studies they produce and support. This technique does not possess all of the advantages of experimental design and does not serve as a replacement for that approach. Similar to stratification and modeling, matching cannot account for the consequences of unmeasured or misclassified confounding variables (Higgins, 2011). Although randomized control trials should be the preferred approach, propensity score matching is well-supported as an ideal technique for observational studies.

A commonly used alternative to propensity score matching is statistically controlling for the effects of covariates on the outcome variable. Some favor matching to the regression adjustment approach because it produces a balanced baseline between treatment and comparison groups, separates the design and analysis of a study, and allows for the examination of the overlap in distributions of the treatment and comparison groups (Austin, 2011). Statistically controlling for these effects using a multivariate method, however, introduces the possibility of inflated and asymptotically-biased estimates (Guo & Fraser, 2010). This is commonly referred to as the "strongly ignorable treatment assignment assumption" (SITA) (Rosenbaum & Rubin, 1983). Violation of this assumption may be more likely to occur in multivariate models because the control variables may contain systematic bias (Heckman, 1979).

The "stable unit treatment value assumption" (SUTVA) is also present in analysis that accounts for covariance. SUTVA assumes that the provision of each, different treatment variable is independent of one another. Violation of the SUTVA assumption occurs when these treatment effects are not independent (Rubin, 1980). When the SUTVA is violated, casual inferences from these results will be inaccurate (Rubin, 1986;

Heckman, 2005). Propensity score matching was used in this study because it helped to mitigate the risk of violating either the SITA and/or SUTVA that could potentially occur using alternative methods (Rubin, 1977).

A propensity score represents the conditional probability of receiving a treatment in an observed study (Rosenbaum & Rubin, 1983). The propensity score, constructed from relevant covariates that predict a person's likelihood to receive treatment, is used to match similar cases in the treatment and the comparison groups. These similar groups are then used for post-matching analysis.

Once missing data are treated, a propensity score (P-score) was produced for each case using the proposed matching variables. The P-score is a summary of the information provided by the covariates included in the matching procedure. Those cases with the same P-scores have similar distributions (Rosenbaum & Rubin, 1983). To ensure that the P-scores were properly balanced according to their distributions prior to matching, a bivariate t-test was conducted to compare the distributions of the treatment and comparison groups according to significance. Alternative to assessing significance, comparison of confidence intervals across groups would provide the similar information regarding the imbalance between groups. Confidence intervals may be considered more informative because they provide insight into a difference in means over an infinite sequence of replications (Cummings, 2013). Significance is ultimately used to assess the imbalance between groups because it provides a defined marker for identifying remaining imbalance.

In this preliminary analysis if non-significant results were produced, the P-scores were considered balanced, and matching procedures were performed. If this analysis

indicated that the differences between the treatment and comparison groups were still significant, alternative combinations of matching variables were used until the groups were found to have similar distributions. There is no definitive procedure to guide the selection of the appropriate matching variables, there is no limit how many matching trials should be conducted so existing literature will be used to aid in this selection process (Smith & Todd, 2005).

Once balanced P-scores were obtained, greedy matching was used. Greedy matching is the most common and precise matching technique that uses P-scores to match cases. Matching was conducted using a 1-to-1, nearest neighbor, within a specified caliper, without replacement approach. This technique matched cases according to individual P-scores, one comparison case to one treatment case. Nearest neighbor matches are those that are closest in P-score within a predetermined range called a "caliper." A caliper is the limit of the range for matching P-scores, and the recommended caliper of .25 was used (Guo & Fraser, 2010). With this technique and without replacement, cases were only matched to one other value. Once the case was matched, it was not re-introduced to the sample as a potential match for other cases.

Post-Matching Analysis

Once similar treatment and comparison groups were constructed, a post-matching analysis was conducted to address this study's research questions. Multivariate analysis designed to control for the influence of covariates was not required due to the similarity of the matched groups, but did serve as a valuable comparison to the propensity-score matched findings. Using the standard 12-month follow-up time period, event-history analysis was conducted to identify both the survival and hazard functions of recidivism

for the treatment and comparison groups. The hazard function provided the probability of recidivism at certain times over the 12-month post-sentence termination, follow-up time frame, and the survivor function provided the probability of not recidivating at certain times over this same observation period.

To assess if the imposition of the ignition-interlock device affected a DWI offender's compliance with probation conditions, a Cox regression analysis was performed. The outcome variables were regressed onto the treatment variables, which were measured by the number of technical violations during the probation sentence. The primary function of the Cox regression analysis is to provide the probability of a probation-condition violation at any given time during the varying probation sentence terms.

To address the fifth research question, which pertains to the differences between multivariate analysis and matched-group analysis in observational studies, a multivariate regression model was used. The primary objective was to identify any effect differences between a multivariate regression technique that controls for the effects of covariates and analysis involving matched treatment and comparison groups. For an appropriate comparison of both techniques, the covariates included in the matching procedure were also included in the multivariate regression model. A separate model was run for each treatment variable. The entire observation time period was used, and DWI recidivism was the outcome variables. A bivariate regression was conducted using the matched samples for each treatment variable, also using the entire observation time period, and also employing DWI recidivism as the outcome variable.

Finally, a supplemental analysis is conducted assessing the interaction between the pretrial and probation treatments. In the primary analysis, the three treatments are mutually exclusive. In the supplemental analysis having the device during either the pretrial or the probation phase is treated as an interaction. Logistic regression is used to assess if this interaction alters the effects of the ignition-interlock device on the occurrence of DWI recidivism.

To summarize, this study began with assessment of whether the missing values are missing completely at random. Once this was complete, the datasets were merged using the person's state identifying number. Following this, matching procedures were performed on the larger, merged dataset. To assess the success of both of these procedures, descriptive statistics and t-tests were performed to identify any remaining significant differences across the groups. Once these procedures were successfully completed, post-matching analysis was conducted to address the study's research questions.

V. PRE-MATCHING DATA TREATMENT AND MATCHING PROCEDURES

To prepare the data for the matching procedure, missing values must be removed or treated in the data. Matches across treatment and comparison groups were made according to the likelihood of receiving treatment. Because each of the three post-arrest interlock treatments, pretrial, probation, or combined pretrial and probation, are different, three mutually exclusive matched samples were constructed.

Missing Data

The dataset used for analysis was constructed from a merged dataset with data from Travis County Pretrial Services, Travis County Community Supervision and Corrections (CSCD), and Texas Department of Public Safety (DPS). The Travis County Pretrial Services dataset contained arrest and bonding information on all persons arrested in Travis County, TX between February, 2007 and October, 2010. The dataset from Travis County CSCD contained information on people in the pretrial sample who were subsequently sentenced to probation, totaling 6,613 cases, accounting for the 13 cases lost due to mismatched state identifying numbers. To conduct the matching procedure, all missing data had to be deleted from the sample. Those cases that contained missing values were, on average, the same as those with all data values. Both subgroups, those with missing values and those without, were, on average, age 30, male, employed full-time, white non-Hispanic, and single. To assess whether the missing values were missing at random, a difference in means t-test was performed on the missing values and the treatment variable. To do this, the missing values from the variables used in each matching procedure were coded as one and compared to the each treatment variable.

There were a total of 3,100 missing values across all matching variables in the comprehensive dataset (see Table 2). Difference-in-means tests were conducted for each variable included in each matching trial. Table 2 reports the t-values for the t-tests comparing cases with missing values and cases without, for each treatment sample. For example, the t-value for prior felony under the pretrial interlock sample of .07 indicates that there is not a statistically significant difference between the mean prior felony convictions of cases with missing values and the pretrial treatment cases. A non-significant difference in means across all treatment groups indicates that the missing values were missing at random. These random missing values have the same probability of being observed as being unobserved (Rubin, 1976). Because the missing values meet the missing-at-random criteria, imputation was not required for the matching procedure, and the cases containing missing values were removed from the sample. This resulted in an additional loss of 2,807 cases and a sample of 3,796 cases to conduct the matching procedure.

Table 2. Missing Data T-Test

Matching Variable	Missing values	Pretrial Interlock t-value	Probation Interlock t-value	Pretrial and Probation Interlock t-value	No Interlock t-value
Employment	1	-.35	-.39	-.30	.69
Race	9	1.09	-.19	-.91	-.05
Marital status	4	.91	.69	1.20	-1.81
Risk	920	-.83	.53	1.02	-.43
Need	919	-.82	.01	.02	-.46
Prior felony	1005	.07	-.14	1.10	-.59
Bond release	242	-.21	.95	-1.50	1.65

** $p < .05$, *** $p < .001$

Note. Matching variables: Age, Number of Dependents, Prior DWI's, Alcohol Counseling, Supervision Condition and Released on Personal Recognizance bond did not contain any missing values.

Matching Procedure

Propensity score matching was used to remove selection bias and balance the treatment and comparison groups according to variables that could influence selection into the treatment group. The ignition-interlock condition imposed during the pretrial, probation, or both pretrial and probation phases was not randomly assigned, but rather assigned by judicial authorities. This device is used as a corrective method to reduce an individual's risk of committing a DWI. Because of this, there is a difference in the risk of DWI offending between those who did and did not install or receive an order to install the device that must be taken into account in this study.

A separate matching procedure was conducted for each treatment group. Imposition of the ignition-interlock device during pretrial, probation, or both phases is reliant on the risk of future offending. Greedy, one-to-one matching was used to construct the separate matched samples. Overall, 52% of the larger, comprehensive sample was included in the final samples. All treatment cases with the exception of one order to install probation case was included and 35% of the total comparison cases were matched to the treatment. The variables, however, that predict this imposition vary across treatments requiring individual matching procedures. A statistical-significance approach was used to identify the optimal matching model. This involves using the statistical significance of each matching variable as a guide for identifying the optimal matching model. Using this approach, variables that have statistically significant effects on admission into treatment are considered ideal for the matching model (Caliendo & Kopeinig, 2005).

A three-step process was used for each matching trial. First, a combination of matching variables was selected for the matching trial, and the propensity of receiving treatment was calculated using a multivariate logistic regression. Second, greedy, one-to-one matching was used to then match a case that received treatment to a case that did not receive the treatment during any post-arrest phase. A caliper of .25 was used as the parameter for the maximum distance between propensity scores of matched treatment and comparison cases. This means that one-quarter of a standard deviation above or below the treatment P-score set the range of acceptable distance for a matched comparison case's P-score. A nearest-neighbor matching criterion was used, so matched cases were those closest to each other in P-score. These matches were made without replacement so that a single comparison case was not used more than once in any matching procedure.

Third, after the matching trial, two bivariate, difference in means t-tests were used to identify any differences that still remained across the treatment and comparison groups for each matching variable included in the trial. The first t-test was the difference in means per matching variable, and the second t-test was the difference in means per matching variable in quartiles.

The initial matching trial for each treatment group included all empirically significant predictors of receiving the ignition-interlock device treatment, such as age, gender, employment status, race, number of dependents, marital status, total criminal risk level, total criminal need level, prior felony convictions, prior DWI convictions, alcohol treatment and supervision, and type of bond release. Table 3 reports the optimal matching models for each matched treatment sample. These matching variables were used to construct the score that represents the propensity to receive treatment, using a

multivariate logistic regression analysis (see Table 3).

Table 3. Matching Variables per Interlock Treatment

Covariates	Pretrial Interlock	Probation Interlock	Pretrial & Probation Interlock
Age	X	X	X
Gender	X	X	X
Employment	X	X	X
Race	X	-	-
Number of dependents	-	-	-
Marital status	-	-	-
Total risk level	-	X	X
Total need level	-	-	-
Prior felony conviction	X	X	X
Prior number of DWI's	X	X	X
Alcohol treatment ordered during bonding	X	X	-
Supervision ordered during bonding	X	-	-
Type of bond release	-	-	-

Note. X = Covariate in matching, - = Covariate not used in matching

Matching variables that were found to have a statistically insignificant influence on receipt of treatment were eliminated from the subsequent matching trial. For each matching trial, the empirically relevant matching variables were re-introduced one at a time until a fully balanced model was obtained. This approach was used to obtain a parsimonious matching model, while also including as many empirically relevant variables as possible. A fully balanced matching model is void of any significant differences across treatment and comparison groups that also have the smallest number of matching variables.

At least three trials were completed for each combination of matching variables. There were no significant differences across treatment and comparison groups for each

final matching model. Furthermore, differences across the treatment and comparison groups are reduced for all matching variables in the final model. Table 3 reports the variables included in each optimal matching model.

Matching variables excluded from all three matching models were the number of dependents, marital status, total need level, and type of bond release. Each matching model contained six to eight matching variables. The optimal pretrial matching model had eight matching variables; the probation model had seven; and the optimal pretrial and probation matching model contained six matching variables. Matching variables used in all three matching models included age, gender, employment, prior felony conviction, and number of prior DWI convictions, which are also the strongest predictors of DWI recidivism in the existing literature. Race, total risk level, alcohol treatment, and supervision treatment order were all used in at least one matching model.

Rosenbaum's sensitivity analysis was used after each optimal model was identified for each treatment group. This analysis was used to identify any unobserved variables or hidden biases still present in the matching model that could influence the assignment of the treatment variable. If the sensitivity analysis produces insignificant upward bound (mh+) and downward bound (mh-) values, then problematic hidden biases that affect treatment assignment may be present (Rosenbaum, 2002). Sensitivity to any alcohol or non-alcohol recidivism was tested, and no problematic hidden bias was found. Across all three treatment groups, the power of the treatment effect increased along with the gamma. This means that as the probability of receiving treatment increased, so too did the average treatment effect (see Appendix B).

Pretrial Treatment Optimal Matching Model

The pretrial matching procedure resulted in matches for all treatment cases with a total sample size of 312 (treatment = 156, comparison = 156). The variables included in the optimal matching model were those that influence the likelihood of being ordered to use the ignition-interlock device as a condition of pretrial bond release. In Travis County, TX this order can be made by the magistrate judge that approves the defendant's release on bond or the defendant's trial judge. This order may be given as a result of Texas Penal Code § 49.01 requiring the condition for defendants who have a prior DWI conviction within 10 years of the DWI arrest or at the judge's discretion.

Table 4 reports the average differences between the unmatched comparison cases, and the matched comparison and treatment groups. The unmatched comparison cases represent all of the comparison cases in the larger sample and the matched comparison and treatment are the cases included in the final matched sample. The matched comparison group reduced differences across all variables compared to the unmatched comparison cases. The percent bias reduction reports the amount of difference between the treatment and comparison cases removed by the matching procedure. The greatest overall reduction in the difference was found for age and prior number of DWI's, corresponding to a percent bias reduction of 83% for age and 87% for number of prior DWI's. The reduction in differences across prior number of DWI's is important because it accounts for such a large number of offenders with prior DWI's who are required by law to install the device. The greatest percent of bias reduction was for gender (91.2%), alcohol treatment during bonding (94.9%), and supervision ordered during bonding (96.7%) (Table 3).

Table 4. Pretrial Treatment Matched Sample Descriptives

Matching variables	Unmatched Comparison Cases		Matched Comparison		Treatment		Percent Bias Reduction
	Mean	*SD*	Mean	*SD*	Mean	*SD*	
Age	36.07	10.12	38.84	9.23	40.13	10.09	82.5
Gender	1.29	.46	1.16	.37	1.20	.41	91.2
Employment	1.53	.99	1.44	.91	1.50	.95	59.7
Race	1.56	.70	1.63	.68	1.63	.78	65.9
Prior felony conviction	.09	.34	.16	.48	.14	.43	81.0
Prior number of DWI's	.15	.42	.82	.73	.83	.61	87.0
Alcohol treatment ordered during bonding	1.25	.43	1.90	.30	1.88	.33	94.9
Supervision ordered during bonding	1.03	.17	1.07	.26	1.10	.30	96.7
Total	2,810		156		156		

Note. *SD* = Standard Deviation.

The average number of prior DWI convictions varies across matched treatment sample. Table 5 reports the frequency of cases according to prior DWI convictions for each matched treatment sample. Across the three samples, the matched pretrial treatment and combined pretrial and probation treatment samples had a higher percentage of repeat offenders than those who only received the order to install the ignition-interlock device during the probation phase (Table 4).

Table 5. Prior DWI Descriptives

Number of prior DWI convictions	Pretrial Sample (% of sample)	Probation Sample (% of sample)	Pretrial and Probation Sample (% of sample)
None	98 (31.41%)	939 (73.13%)	125 (32.38%)
One	174 (55.77%)	276 (21.50%)	211 (54.66%)
Two	36 (11.54%)	61 (4.75%)	48 (12.44%)
Three+	4 (1.28%)	8 (.62%)	2 (.52%)
Average DWI prior	.83	.33	.81
Total	312	1,284	374

This illustrates one advantage of propensity score matching because the average number of DWI prior convictions for the total non-treatment cases was .15 compared to .83 for those receiving the pretrial treatment (Table 3). After the matching procedure, this difference across averages for prior DWI convictions was eliminated with a mean of .83 for the treatment group and mean of .82 for the matched comparison group (Table 4).

Probation Treatment Optimal Matching Model

The optimal matching model for the probation treatment sample was the most precise of the three samples with the least amount of differences between the treatment and comparison groups. Although three matching trials were performed for the probation treatment sample, the matching model from the second trial was optimal because it had the greatest number of matching variables, with the most imbalance removed across groups. One case in this matching procedure was lost due to a failed match. The other treatment groups did not have any failed matches in their final matched sample.

Table 6 reports the differences across treatment and comparison cases and the percent of bias reduced due to the matching procedure for the probation-matched sample. The difference between the treatment and matched comparison group had the greatest, overall reduction for age, total criminal risk, and number of prior DWI convictions (Table 5). The greatest percent of bias reduced as a result of the matching procedure was for employment with 96.4% (Table 6). The probation-matched sample was on average 1.40 years younger than the unmatched comparison cases. The matching procedure reduced the average age difference by .43 years, on average.

Table 6. Probation Treatment Matched Sample Descriptives

Matching variables	Unmatched Comparison Cases		Matched Comparison		Treatment		Percent Bias Reduction
	Mean	*SD*	Mean	*SD*	Mean	*SD*	
Age	36.07	10.12	34.24	9.70	34.67	10.43	83.8
Gender	1.29	.46	1.29	.45	1.30	.46	74.7
Employment	1.53	.99	1.50	.95	1.57	1.00	96.4
Total risk level	1.53	.71	1.71	.73	1.71	.72	78.8
Prior felony conviction	.09	.34	.08	.31	.10	.35	85.9
Prior number of DWI's	.15	.42	.32	.59	.34	.60	69.8
Alcohol treatment ordered during bonding	1.25	.43	1.39	.49	1.38	.48	76.8
Total	2,810		642		642		

Note. *SD* = Standard Deviation.

Table 7 reports the average criminal risk for each matched treatment sample. About half of the probation matched sample had a minimum criminal risk level (45.25%) compared to the pretrial and probation treatment group that had a majority of medium risk offenders (43.78%) (Table 7). The average criminal risk level for the pretrial and pretrial and probation matched treatment samples was higher, compared to the probation treatment sample. Furthermore, the pretrial and combined pretrial and probation treatment samples had higher percentages of maximum risk offenders than the probation treatment matched sample (Table 7). This indicates that imposition of the ignition-interlock device during pre-conviction, post-arrest phases may be justified by the offender having a higher risk level.

Pretrial and Probation Treatment Optimal Matching Model

The optimal matching model for the combined pretrial and probation sample contained the fewest number of matching variables. This treatment group had the highest average criminal risk level and fewest number of treatment cases. This is because the imposition of the ignition-interlock device during both post-arrest phases is perceived as appropriate for those with the highest risk of DWI recidivism (Table 7).

Table 7. Risk Descriptives

Risk	Pretrial Sample (% of sample)	Probation Sample (% of sample)	Pretrial and Probation Sample (% of sample)
	n (%)	*n* (%)	*n* (%)
Minimum	122 (39.10%)	581 (45.25%)	138 (35.75%)
Medium	130 (41.67%)	498 (38.79%)	169 (43.78%)
Maximum	60 (19.23%)	205 (15.97%)	79 (20.47%)
Average risk	1.80	1.71	1.85
Total	312	1,284	374

Table 8 reports the change in differences between treatment and comparison cases due to the matching procedure for the combined pretrial and probation treatment sample. The averages of the characteristics of each matched treatment sample differ because use of the ignition-interlock device, as a correctional method, differs according to these post-arrest phases. The combined pretrial and probation interlock treatment is imposed the earliest and for the longest of all the interlock treatments. Interestingly, the greatest reduction in mean differences across treatment and comparison groups was in the number of prior DWI's for all treatment groups. For the combined pretrial and probation there is an 83.5% bias reduction after the matching procedure for the number of prior DWI's (Table 8). This is predictive of both receiving an interlock treatment during any post-arrest phase and DWI recidivism. This alone is justification for propensity score

matching that allows for a more robust and rigorous method of analysis for quasi-experimental studies.

Table 8. Pretrial and Probation Matched Sample Descriptives

Matching variables	Unmatched Comparison Cases		Matched Comparison		Treatment		Percent Bias Reduction
	Mean	*SD*	Mean	*SD*	Mean	*SD*	
Age	36.07	10.12	39.73	10.67	40.26	9.94	87.4
Gender	1.29	.46	1.20	.40	1.20	.40	74.7
Employment	1.53	.99	1.37	.83	1.42	.96	59.7
Total risk level	1.53	.71	1.86	.75	1.83	.72	91.8
Prior felony conviction	.09	.34	.09	.38	.09	.35	37.4
Prior number of DWI's	.15	.42	.81	.70	.81	.61	83.5
Total	*2,810*		*187*		*187*		

Note *SD* = Standard Deviation.

VI. POST-MATCHING ANALYSIS AND RESULTS

Once matched samples were constructed for each treatment type, post-matching analyses were conducted to assess the effects of installing the device or an order to install the ignition-interlock device. This chapter provides an explanation of what analyses were conducted, and the results for both DWI and non-alcohol recidivism outcome measures. The risk to, and time to re-offend are assessed along with the ignition-interlock's effects on compliance with conditions of probation. Also provided are results from the comparison of logistic regression models using matched and random samples to address the methodological inquiry about the differences in these techniques. Finally, a supplemental analysis assessing the ignition-interlock device treatment during both the pretrial and probation phases as an interaction is conducted.

Post-Matching Analysis

A variety of post-matching analyses, including event history and multi- and bivariate regression, were used to address the research questions. General inquiries were made about the effects of the ignition-interlock device on the likelihood of recidivism, time to recidivism, and likelihood of compliance with conditions of probation. The treatment's effects on the likelihood of recidivism and likelihood of probation compliance were tested using general proportional hazard, Cox regression models, and survival analysis. To address the methodological inquiry about the differences and similarities between propensity score matching and alternative methods of controlling for confounding variables, multi- and bivariate logistic regression was used, and the results were compared.

The amount of time the ignition-interlock device was imposed varies according to treatment program, as reported in Table 9. Interestingly, the pretrial treatment group had

the longest average pre-conviction days from arrest to probation sentence, spanning, on average, an additional three weeks longer than either the probation or the combined pretrial and probation treatment groups. The average probation term and long-term follow-up period were similar in average number of days across the three treatment groups. The smallest difference across groups in time period was the amount of time in the pre-conviction, pretrial phase, varying from 309 to 338 days, on average (Table 9). Alternatively, the greatest difference in time periods across these groups was the number of days the ignition-interlock device is installed. The combined pretrial and probation treatments were one-third shorter in average number of treatment days compared to the pretrial and probation treatments (Table 9). This treatment group also had the shortest number of average days on probation-552 days compared to the pretrial group's average of 565 days and combined pretrial and probation treatment group's average of 637 days. The average total observation time for each group ranged from, 2,156 to, 2,279 days (Table 9).

Table 9. Treatment Sample Time Period Descriptives (Average Number of Days)

Treatment Group	Days of treatment	Time Pre-conviction	Probation Term	Total Time in System	Short-term Time Period	Long-term Time Period
Pretrial	325	338	565	2279	364	1393
Probation	284	313	552	2156	364	1292
Pretrial and Probation	973	309	637	2264	364	1318

Two time interlock intervals were examined; the time on the interlock ("installed"), from the installation or order of the installation of the device to the expiration of the order; and the post-interlock period ("uninstalled") following after the expiration date to the end of the follow up period. For the purposes of this study order

expiration is equated to device removal because date of removal was not available information. This is a limitation of the data because, although unlikely, some offenders may elect to continue use of the ignition-interlock device after it is no longer required by the court. A combination of time periods when the device was installed and uninstalled were examined to compare both the incapacitation effects of the device while installed and the possible deterrent effects after the device was removed. Using the intent-to-treat perspective, the removal of the device was measured by the expiration of the installation order at the end of the installation time period.

DWI Recidivism

To answer the question if the installation or order of installation of the ignition-interlock device reduced the likelihood of DWI recidivism, partial likelihood models of the treatment and comparison groups are compared to assess the average treatment effects on the hazard of recidivism. This analysis measured the probability of recidivism occurring per day for those individuals who had not had an observed event during the observation time period and were still at risk of an event occurring (Cox, 1972).

The time periods described in Table 10 span day of arrest to the last day of the observation period. The "Installed" time period represents the time the device was installed for each treatment group. Time periods that include both installation and after device removal for each treatment group are labelled "Install/Uninstall" followed by short-term or long-term. The short-term time period spans one year after the device is removed and the long-term time period ends at the end of the study's observation time period. The time periods that are exclusively after the device is removed are referred to as "Uninstall."

The hazard ratios in Table 10 represent these recidivism probabilities if the ignition-interlock device was installed over the observed time period. For example, those who used the device during the pretrial, post-arrest phase had a hazard of .10 recidivism risk, while the device was installed. This corresponds to a 90% reduction in the risk of DWI recidivism over this time period with a 95% confidence interval of .01 to .83 (Table 10). This means that the reduction of risk of DWI recidivism is likely from 17% to 90% in the population. This wide range indicates this risk reduction probability lacks precision as a predictive measure.

The number need to treat (NNT) is also displayed in Table 10. This value represents the average number of individuals who would need to receive treatment for the benefit of treatment. For example, the NNT of the pretrial ignition-interlock treatment while installed of 26 indicates that 26 individuals, on average, would have to receive this treatment for one less DWI recidivism outcome to occur. The lower the NNT the more effective one can consider the treatment because fewer need to be treated to reduce the occurrence of the outcome.

The observed recidivism events for all time periods were larger for the comparison group than the matched treatment groups (Table 10). This means that those who received the treatment engaged in less DWI recidivism than those who did not receive treatment, regardless of when the observation of recidivism began, or how long this time period lasted. Overall, for all three of the treatment groups, there was a lower percentage of DWI recidivism during the entire observation time period, ranging from a four to five percent difference.

Table 10. Hazard Ratios by Treatment Group for DWI Recidivism

	Time Period	Hazard Ratio	95% CI	Observed Events		NNT
				Comparison	Treatment	
Pretrial:	Install	.10	.01-.83	7	1	26
	Uninstall	.46	.18-1.54	12	8	39
	Probation term Install/Uninstall to Short-term	.47	.22-1.00	20	12	20
	Install/Uninstall to Long-term	.72	.40-1.28	39	29	40
	Uninstall to Short-term	.63	.27-1.43	13	11	83
	Uninstall to Long-term	.87	.48-1.61	21	23	83
Probation:	Install (Probation Term)	.55	.34-.87	46	29	37

	Time Period	Hazard Ratio	95% CI	Observed Events		NNT
	Install/Uninstall to Short-term	.64	.44-.93	68	46	29
	Install/Uninstall to Long-term	.72	.53-.97	101	74	24
	Uninstall to Short-term	.77	.41-1.45	22	17	125
	Uninstall to Long-term	.84	.56-1.23	54	45	71
Pretrial and	Install	.46	.21-.99	19	10	19
Probation:	Install/Uninstall to Short-term	.46	.24-.87	27	15	14
	Install/Uninstall to Long-term	.52	.32-.85	42	27	16
	Uninstall to Short-term	.62	.20-1.88	8	5	63
	Uninstall to Long-term	.65	.35-1.22	23	17	100

Note. Short-term period is one year after probation sentence completion. Long-term time period is follow-up until 4/22/2015. CI = Confidence Interval. Install is the time period the device is installed or ordered to be installed. Install/Uninstall to short-term is from the time the device is installed or ordered to be installed to one year after the device order has expired. Install/Uninstall to long-term is from the time the device is installed or ordered to be installed to up to six years after the device order has expired. Uninstall to short-term is one year after the device order has expired. Uninstall to long-term is up to six years after the device order has expired. NNT is the average number of individuals needs to receive the ignition-interlock treatment for an additional outcome to not occur.

The most consistent estimates across treatment samples were found while the device was installed. The average treatment effect during this time period indicates negative effects on DWI recidivism (Table 10). Only the time periods estimating the probability of recidivism after the device was removed were not likely to occur in the population beyond chance. For example, one year after device removal, those who had the device during the probation phase had a .77 hazard or 23% risk of DWI recidivism. That risk is not beyond chance with a 95% confidence interval spanning .41 to 1.45 (Table 10).

In contrast, the short- and long-term time periods, including both installation and after device removal, revealed positive effects for the treatment group on the probability of DWI recidivism. Those who had the ignition-interlock treatment as a condition of probation, on average, had a 36% lower risk of DWI recidivism one year following device removal with 95% CIs [.44, .93], equaling 22 more DWI recidivists in the comparison group out of a total of 111. Those who had the device from release on bond to probation sentence termination had a 54% lower risk of DWI recidivism one year after the device was removed with 95% CIs [.32, .85] (Table 10).

There are 12 more DWI recidivists in this matched sample's comparison group out a total of 42. These probability estimates are the most precise of all probability estimates with 95% confidence intervals ranging 44%. These confidence intervals are relatively close to 1, which is the risk of no treatment cases experiencing DWI recidivism during the observation time periods. This means that there is a 95% chance the reduction in DWI recidivism risk could be slight, in the population.

The long-term average treatment effect was also a reduction in the risk of DWI recidivism for those who used the ignition-interlock device during the probation or the combined pretrial and probation post-arrest phases. With 27 less DWI recidivists out of 175, on average, those who used the device during probation were 28% less likely to commit a subsequent DWI with 95% CIs [.53, .97] up to six years after device removal. Those who had the device during both post-arrest phases had a 48% reduction in likelihood of DWI recidivism with 95% CIs [.32, .85] over the same time period (Table 10). These intervals are also located close to a probability of 1 indicating a chance of small effects from use of the ignition-interlock device.

The NNT's for both of these time periods were also the lowest compared to all other time periods for the probation treatment matched sample. From installation to one year after device removal, on average, 29 individuals required to have the probation interlock treatment could reduce the occurrence of DWI recidivism and 24 from installation to up to six years after device removal (Table 10). This indicates that the probation ignition-interlock treatment from installation to one year or up to six years after device removal is likely the most effective in comparison to other time periods.

The average treatment effects for those most likely to receive the ignition-interlock device as a condition of bond and probation sentence were moderate to high. Interestingly, DWI recidivism for this higher-risk offending group had the lowest average risk of recidivism after the device was removed. The effects of the interlock device on recidivism were larger for those most likely to receive the device during the combined pretrial and probation post-arrest phase, compared to those likely to receive it during only one post-arrest phase. For example, those who had the device during both post-arrest phases experienced a 47% to 54% reduction in the risk of DWI recidivism up to six years after device removal, compared to a 28% to 36% reduction for those who had the device during only the probation phase (Table 10).

Non-alcohol Recidivism

To evaluate if the ignition-interlock device's effects on recidivism beyond DWI recidivism differed across treatment groups, hazard ratios were compared. Table 11 reports the hazard ratios for the risk of non-alcohol recidivism over different observation time periods. Non-alcohol recidivism includes all non-alcohol related offenses, excluding any class C offenses, such as traffic offenses. The pretrial ignition-interlock

treatment had an effect on non-alcohol recidivism beyond chance, only over the longest follow-up time period. Those who had the device as a condition of bond, up to six years after the device was removed, had a hazard ratio of .63 with a 95% CI [.41, .96], this corresponds to a 37% non-alcohol-recidivism risk reduction (Table 11). It is likely that the risk of non-alcohol recidivism is reduced anywhere from 4% to 59% for those who had the device during this observation time period.

The NNT for the pretrial interlock treatment during this time period is 77 indicating that, on average, 77 individuals would need to receive the treatment for a benefit to the occurrence of non-alcohol recidivism (Table 11). Comparatively, all of the probation ignition-interlock device treatment effects on the risk of non-alcohol recidivism across all observation time periods were not likely to occur beyond chance in the population (Table 11). Furthermore, the probation interlock treatment is less effective than either the pretrial or combined pretrial and probation treatments with NNT's ranging from 30 to 91 (Table 11).

Table 11. Hazard Ratios by Treatment Group for Non-alcohol Recidivism

	Time Period	Hazard Ratio	95% CI	Observed Events		NNT
				Comparison	Treatment	
Pretrial:	Install	-	-	12	0	13
	Uninstall	.80	.39-1.66	15	16	39
	Probation term					
	Install/Uninstall to Short-term	.89	.53-1.49	35	33	83
	Install/Uninstall to Long-term	.63	.41-.96	42	44	77
	Uninstall to Short-term	.69	.37-1.29	23	19	39
	Uninstall to Long-term	.83	.49-1.39	30	30	-
Probation:	Install (Probation Term)	1.12	.78-1.61	55	65	67
	Install/Uninstall to Short-term	1.23	.90-1.67	74	92	36

	Time Period	Hazard Ratio	95% CI	Observed Events		NNT
				Comparison	Treatment	
	Install/Uninstall to Long-term	1.24	.95-1.62	99	120	30
	Uninstall to Short-term	1.39	.77-2.50	19	26	91
	Uninstall to Long-term	1.29	.86-1.92	44	54	67
Pretrial and Probation:	Install	.56	.35-.94	39	28	15
	Install/Uninstall to Short-term	.56	.36-.87	49	32	13
	Install/Uninstall to Long-term	.62	.43-.91	64	47	16
	Uninstall to Short-term	.39	.12-1.25	10	4	167
	Uninstall to Long-term	.65	.36-1.19	25	19	200

Note. Short-term period is one year after probation sentence completion. Long-term time period follow-up until 4/22/2015. CI = Confidence Interval. Install is the time period the device is installed or ordered to be installed. Install/Uninstall to short-term is from the time the device is installed or ordered to be installed to one year after the device order has expired. Install/Uninstall to long-term is from the time the device is installed or ordered to be installed to up to six years after the device order has expired. Uninstall to short-term is one year after the device order has expired. Uninstall to long-term is up to six years after the device order has expired. NNT is the average number of individuals needs to receive the ignition-interlock treatment for an additional outcome to not occur.

There are also effects of the ignition-interlock device on non-alcohol recidivism for those who used the device during the combined pretrial and probation post-arrest phases. These effects were while the device was installed, and up to six years after the device was removed. Overall, the ignition-interlock device reduced the risk of non-alcohol recidivism, on average, by about 44% when installed, 44% when installed until one year after the device was removed, and 38% up to six years after the device was removed (Table 11). For this matched sample, the reduction in the risk of non-alcohol recidivism is greater for ignition-interlock users from the time the device is installed until one year after device removal. With a 95% confidence interval that spans .36 to .87, the

risk reduction in the population is likely to be 12% to 64%. Comparatively, while the device is installed and from installation to up to six years after device removal, the risk reduction could be as large as 64% or 65% but as small as 5% or 6% (Table 11).

Imposition of the ignition-interlock device over both post-arrest phases may be more effective in reducing the likelihood of non-alcohol recidivism for those most likely to have the device during this time. Much of the non-alcohol recidivism for the combined pretrial and probation treatment sample occurred early in the observation time period. There were a total of 67 non-alcohol recidivism events while the interlock device was installed during the combined pretrial and probation interlock treatment, compared to only 44 in the six years after the device was removed (Table 11).

Survival Analysis: DWI Recidivism

Survival analysis is used to examine if the ignition-interlock device delays the time to DWI recidivism. Survival probabilities represent the likelihood that a person will not have a recidivism event over the observation time period. The partial likelihood test that is used to examine risk of recidivism produces an inverse result to the hazard ratio. Table 12 reports whether the survival probability for those who did and did not receive the interlock treatment differ beyond random chance. A significant chi-square indicates that significant difference in the survival probabilities, represented by survival curves, between these groups (Table 12). It should be noted the overall probability of DWI recidivism is low. The lowest probability of a non-recidivism event across the three matched samples is about 85%. This means that there is at least an 85% probability that any offender in the sample will not commit a subsequent DWI.

Table 12. Survival Analysis: DWI Recidivism

	Time Period	χ^2
Pretrial:	Install	7.19**
	Uninstall Probation term	4.80
	Install/Uninstall to Short-term	3.95
	Install/Uninstall to Long-term	1.39
	Uninstall to Short-term	3.31
	Uninstall to Long-term	1.35
Probation:	Install	6.66**
	Install/Uninstall to Short-term	5.48**
	Install/Uninstall to Long-term	4.80**
	Uninstall to Short-term	.66
	Uninstall to Long-term	.77
Pretrial and Probation:	Install	4.13**
	Install/Uninstall to Short-term	5.99**
	Install/Uninstall to Long-term	7.15**
	Uninstall to Short-term	.75
	Uninstall to Long-term	1.82

**p< .05

Note. Install is the time period the device is installed or ordered to be installed. Install/Uninstall to short-term is from the time the device is installed or ordered to be

installed to one year after the device order has expired. Install/Uninstall to long-term is from the time the device is installed or ordered to be installed to up to six years after the device order has expired. Uninstall to short-term is one year after the device order has expired. Uninstall to long-term is up to six years after the device order has expired.

Figures 2, 3, and 4 illustrate the differences across the average treatment effects while the ignition-interlock device is installed. These figures show that the survival probability, or probability of non-recidivism, differs by treatment group while the device is installed (Figures 2, 3 and 4). Table 11 reports that the difference between these survival probabilities is beyond chance ($p < .05$) with statistically significant chi-square values of 7.19, 6.66, and 4.13. The probability of non-recidivism is greater for those who had the ignition-interlock device, compared to those who did not have it, during this observation time period. For example, those who had the ignition-interlock device during the combined pretrial and probation post-arrest phases have a four percent higher survival probability 250 days into this observation time period, compared to those who did not have the device (Figure 4). As the number of days increased during this observation time period, the difference between these probabilities grew larger, indicating changes in survival probability at different rates across the treatment and comparison groups. At the end of each matched treatment sample's survival probability, this difference levels out, represented by a flat line on the survival probability curves. These flat lines are a result of several cases with exceptionally long observation time periods that did not have a recidivism event (Figures 2, 3 and 4).

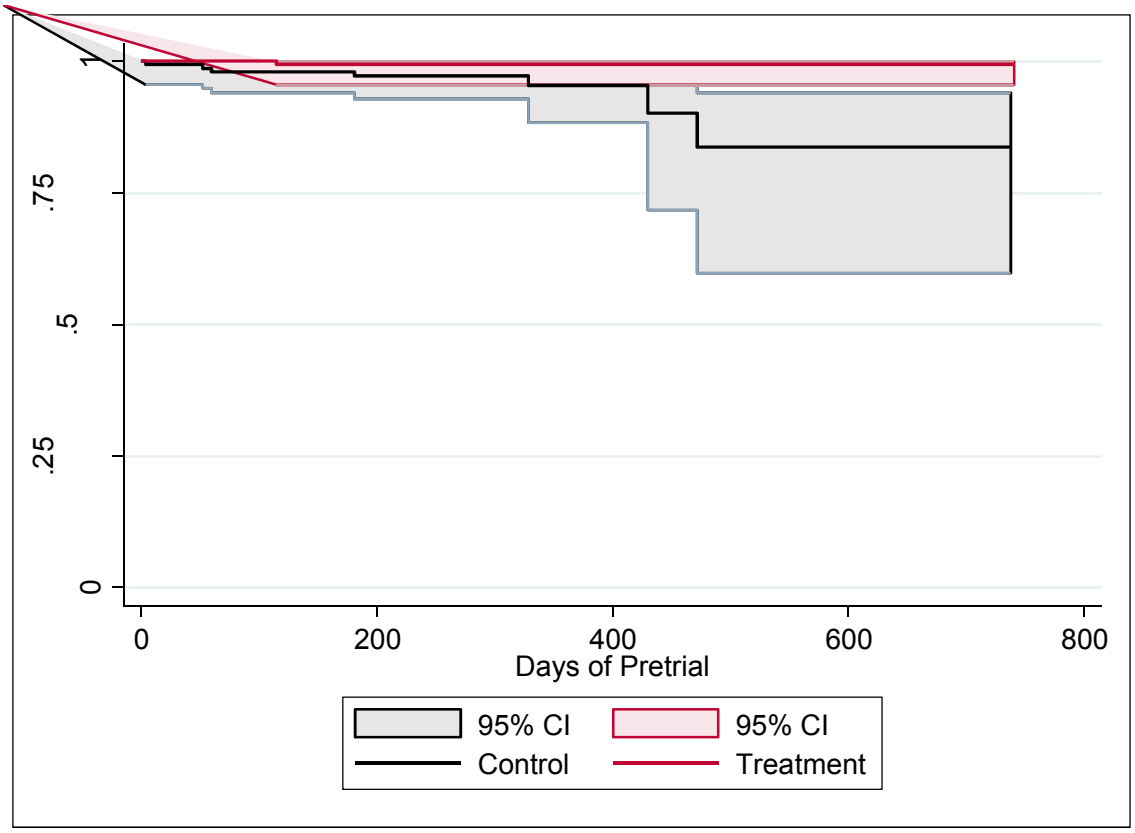

Figure 2. Cox Proportional Hazards Regression Survival Curves: Pretrial Interlock During Installed Period

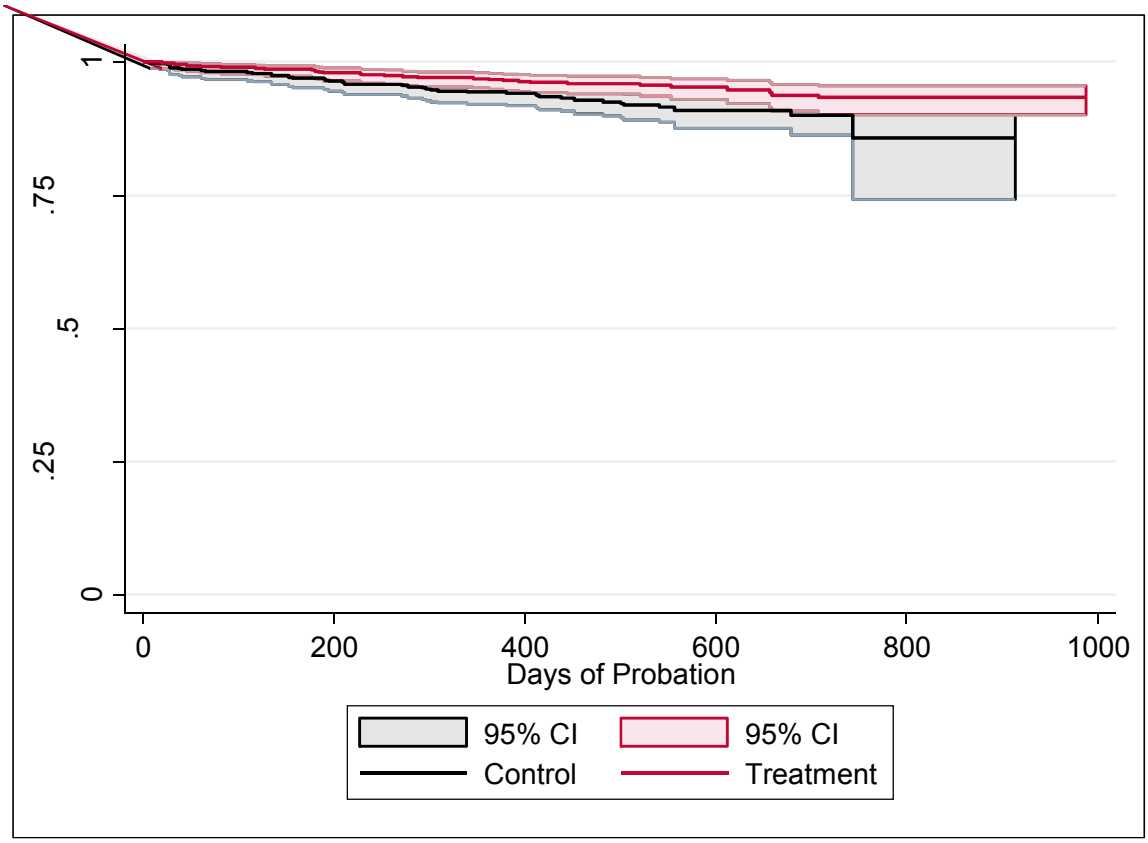

Figure 3. Cox Proportional Hazards Regression Survival Curves: Probation Interlock During Installed Period

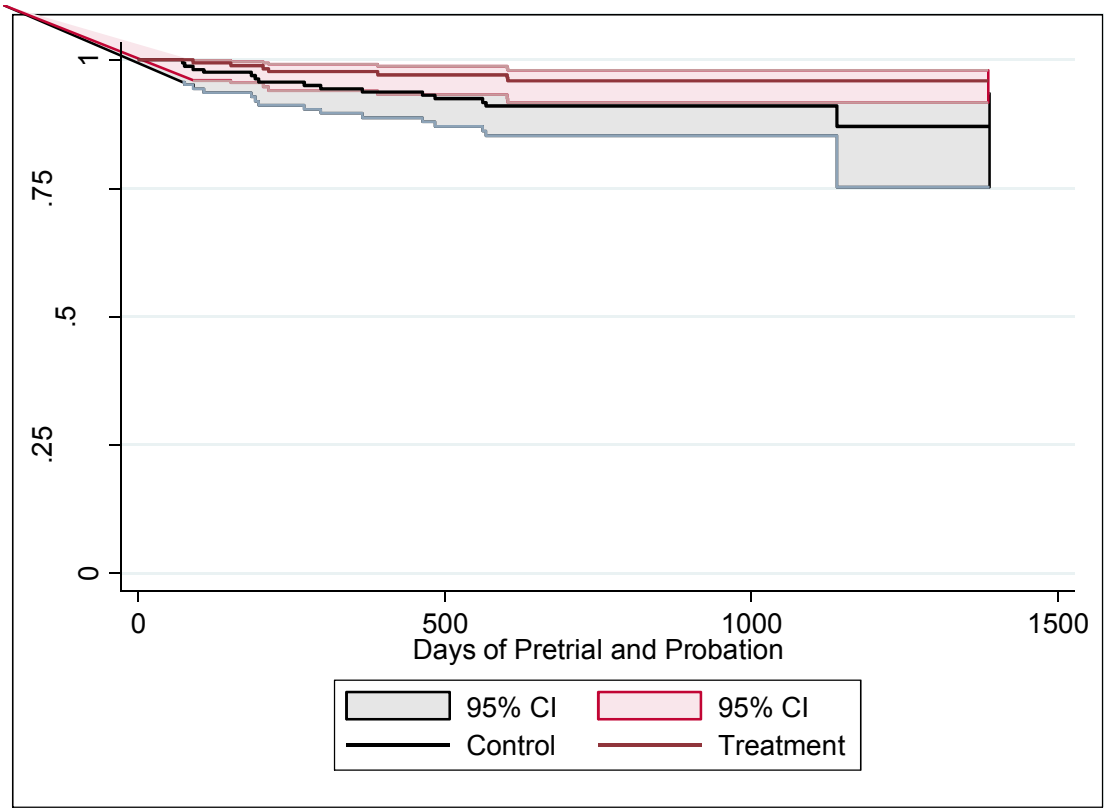

Figure 4. Cox Proportional Hazards Regression Survival Curves: Pretrial and Probation Interlock During Installed Period

Comparatively, for both the probation and combined pretrial and probation treatment groups, there are statistically significant differences in the probability of DWI recidivism from installation to one year after device removal. The survival probabilities across treatment and comparison groups over this time period are represented in Figures 5 and 6.

Over time, the probability of not recidivating for both the probation and combined pretrial and probation matched treatment sample comparison group decreases at a faster rate than those who used the ignition-interlock device. This difference in survival probability continues to grow after the device was removed, on average, for 567 days for the probation treatment group and 973 days for the pretrial and probation group

(Figures 5 and 6).

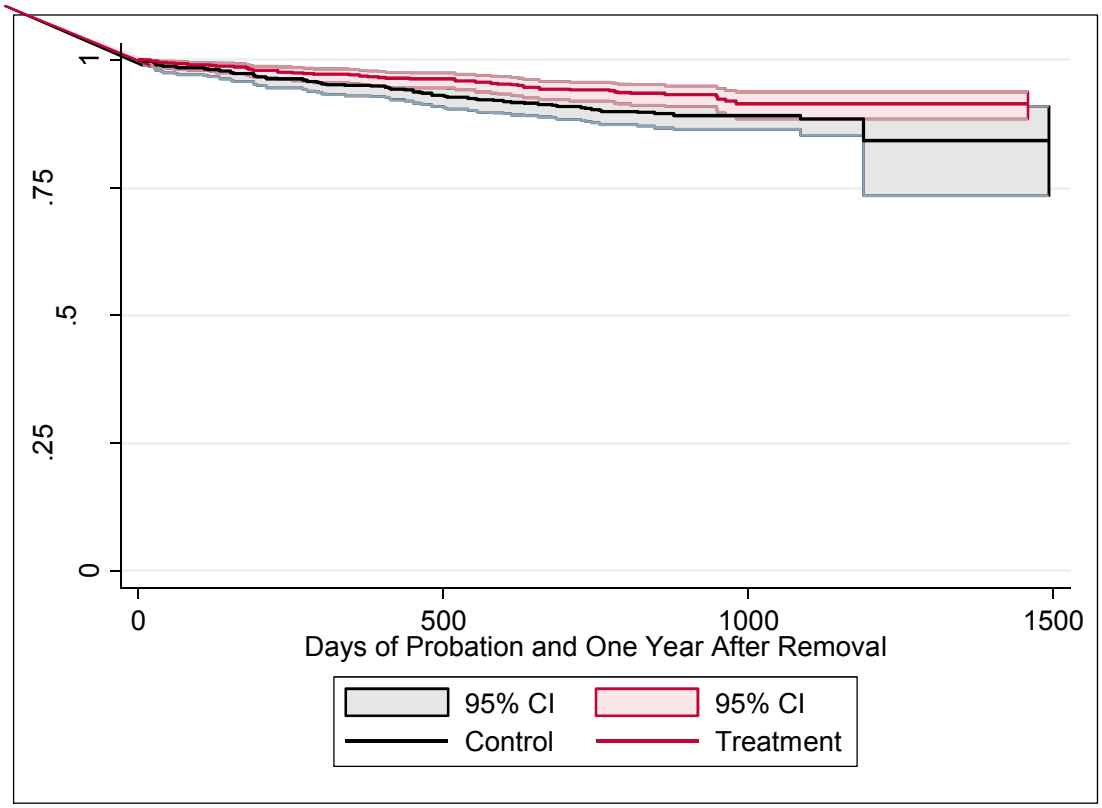

Figure 5. Cox Proportional Hazards Regression Survival Curves: Probation Interlock; During Installation and One Year After Removal

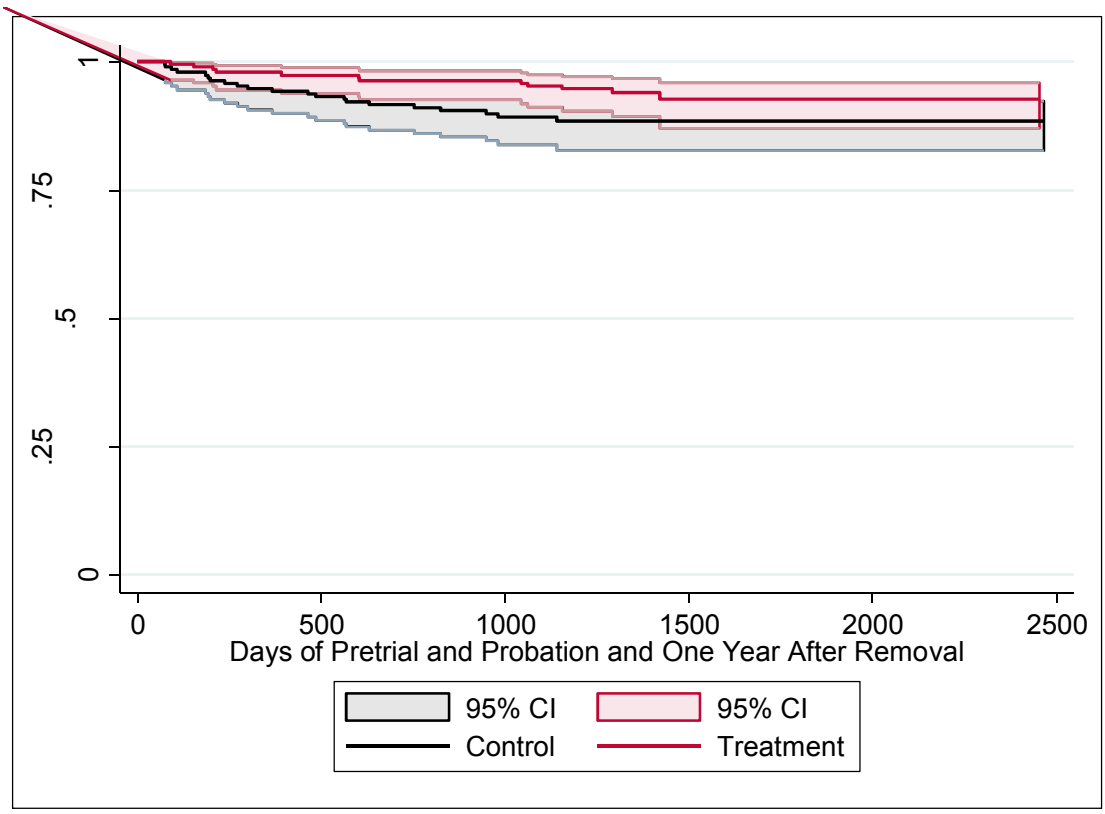

Figure 6. Cox Proportional Hazards Regression Survival Curves: Pretrial and Probation Interlock; During Installation and One Year After Removal

Figures 7 and 8 report survival probabilities across treatment and comparison groups from when the device was installed to up to six years after removal. Differences across survival probability over this long-term follow-up time period were similar to the short-term time period for the probation and combined pretrial and probation matched treatment samples. The probability of DWI recidivism over time decreased faster for those who did not receive the ignition-interlock treatment than for those who did. This decrease occurred gradually over time and was greatest between 1000 and 2000 days after installation of the ignition-interlock device.

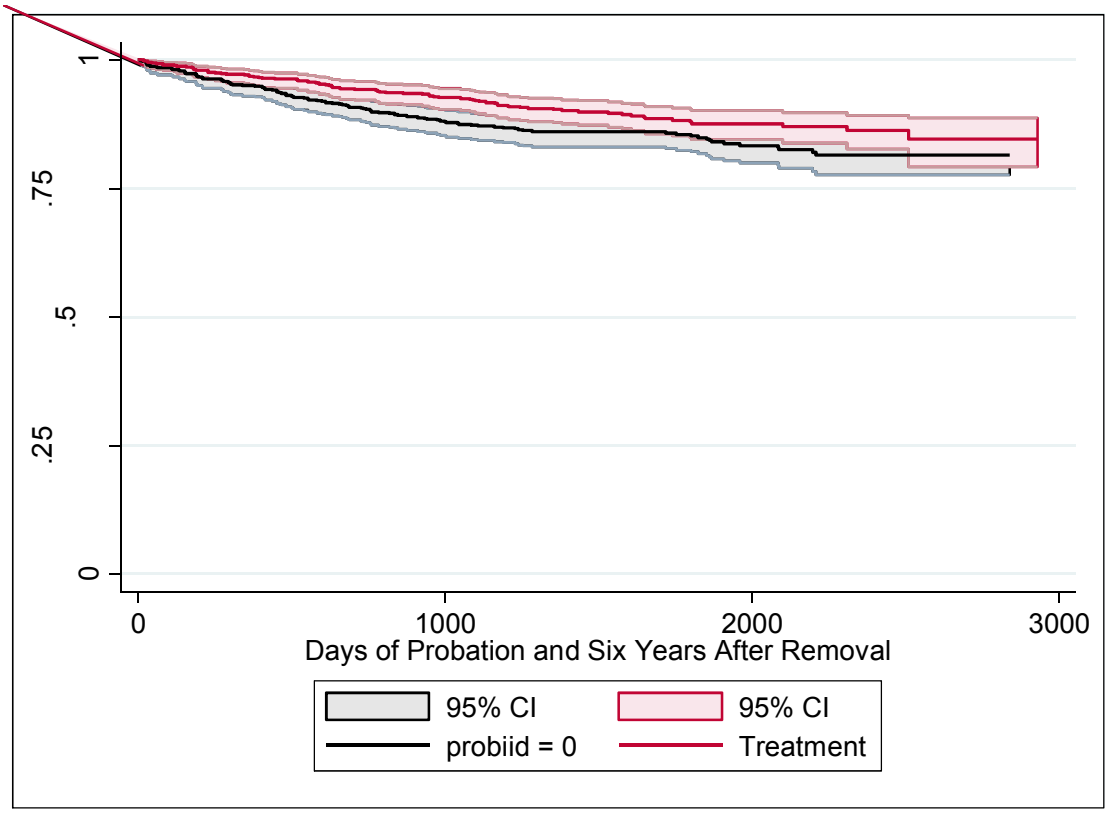

Figure 7. Cox Proportional Hazards Regression Survival Curves: Probation Interlock; During Installation and Six Years After Removal

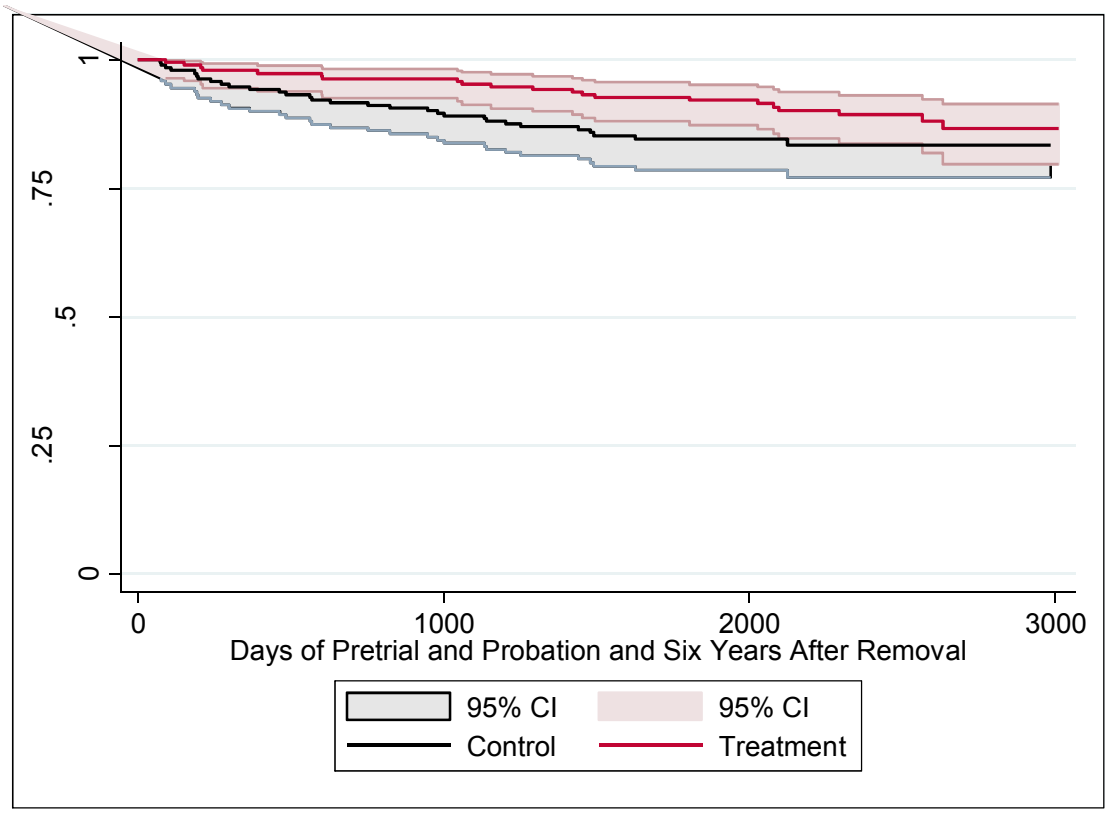

Figure 8. Cox Proportional Hazards Regression Survival Curves: Pretrial and Probation Interlock; During Installation and Six Years After Removal

Survival Analysis: Non-alcohol Recidivism

Survival analysis of the probability of non-alcohol recidivism, assessing if the ignition-interlock device delayed non-alcohol recidivism, produces fewer statistically significant differences represented by a significant chi-square value with a p-value of less than .05. Differences in probability could not be calculated for two time periods for the pretrial matched sample because there was not enough variation in the time to non-alcohol recidivism events across those groups. For both the pretrial and probation matched treatment samples, there were no statistically significant differences across any time period (Table 13). Similar to the probability of DWI recidivism, non-alcohol recidivism among these DWI offenders is low. The offenders in this sample are at least

65% likely to not commit another non-alcohol related offense.

Table 13. Survival Analysis: Non-alcohol Recidivism

	Time Period	χ^2
Pretrial:	Install	-
	Uninstall Probation term	2.85
	Install/Uninstall to Short-term	.18
	Install/Uninstall to Long-term	-
	Uninstall to Short-term	3.09
	Uninstall to Long-term	4.09
Probation:	Install	.40
	Install/Uninstall to Short-term	1.70
	Install/Uninstall to Long-term	2.59
	Uninstall to Short-term	1.18
	Uninstall to Long-term	1.52
Pretrial and Probation:	Install	7.25**
	Install/Uninstall to Short-term	5.86**
	Install/Uninstall to Long-term	3.60
	Uninstall to Short-term	.11
	Uninstall to Long-term	.04

**p< .05

Note. Install is the time period the device is installed or ordered to be installed. Install/Uninstall to short-term is from the time the device is installed or ordered to be installed to one year after the device order has expired. Install/Uninstall to long-term is from the time the device is installed or ordered to be installed to up to six years after the device order has expired. Uninstall to short-term is one year after the device order has expired. Uninstall to long-term is up to six years after the device order has expired.

There were statistically significant differences for the combined pretrial and probation treatment while the device was installed and one year following device removal. Survival probabilities across treatment and comparison groups in Figures 9 and 10 report a greater difference in survival probability of non-alcohol recidivism over time while the device is installed compared to after device removal. Interestingly, the differences in probability level out around 1500 days for each of these survival curves, represented by the flat lines between 1500 and 3000 days of observation. Differences in survival probabilities for those in the combined pretrial and probation treatment group indicate that the interlock's influence on non-alcohol recidivism was only meaningful

when imposed during both of these post-arrest phases.

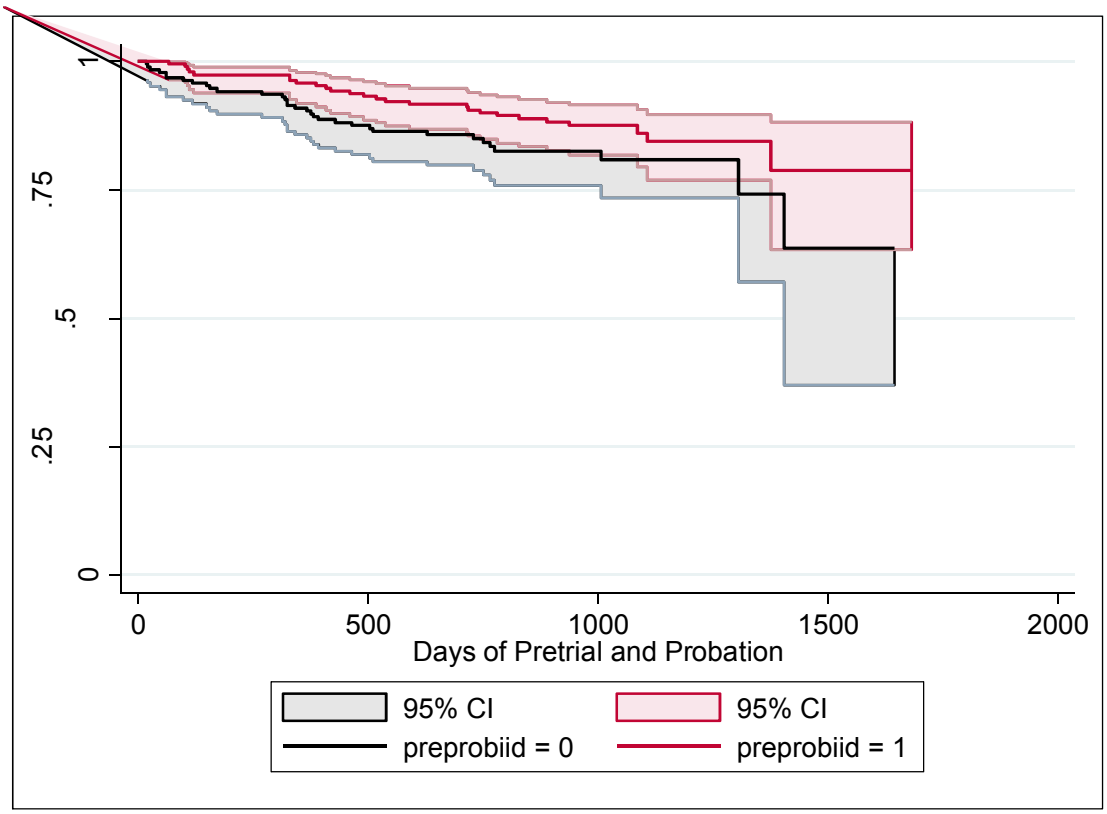

Figure 9. Cox Proportional Hazards Regression Survival Curves: Pretrial and Probation Interlock During Installed Period

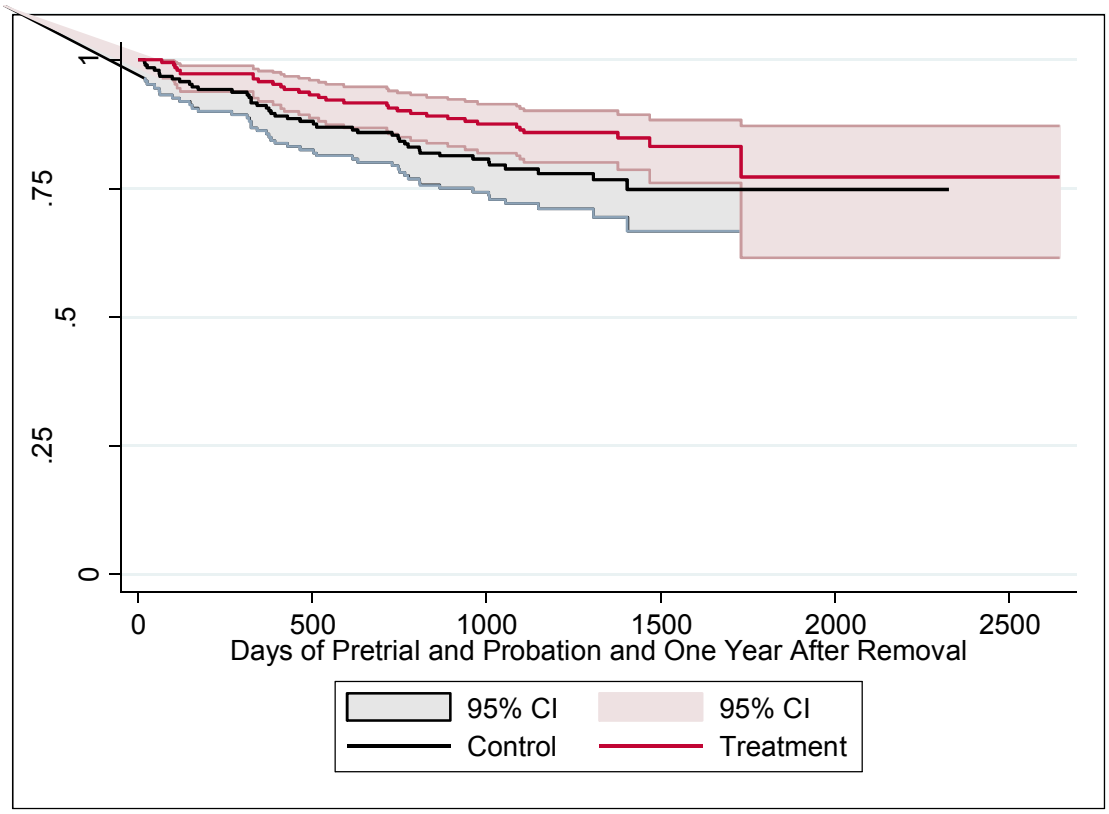

Figure 10. Cox Proportional Hazards Regression Survival Curves: Pretrial and Probation Interlock; During Installation and One Year After Removal

Probation Compliance

Cox regression was used to assess if imposition of the ignition-interlock device during the probation phase affected the likelihood of compliance with the conditions of probation. Non-compliance was measured separately as both non-criminal, technical violations, and commission of a new offense during completion of the probation sentence. Violation of the ignition-interlock device such as circumvention of the device, failure to submit a breath sample for a rolling retest, and submitting a breath sample consistent with alcohol consumption were not included in the technical or new offense violations because this information was not available. Often these violations are addressed informally with the offender by the probation officer. The technical and new

offense violations assessed in this study are formally addressed by the courts. This limitation of the data is another shortcoming of this study. Technical violations include failure to pay fees, positive urine-analysis (UA), failure to appear for office visits, treatment non-participation, and absconding. Failure to pay fees and positive UA were the most common violation reasons for both the pretrial and the probation treatment matched samples. Violation from a new offense was the most common reason for both groups. In total, there were 107 new offense violations and 100 technical violations.

Table 14 reports the Cox regression results for both probation violation types. The greatest average treatment effects of the ignition-interlock device on probation compliance were for the risk of technical violation. Having the ignition-interlock device during probation sentence increased the risk of a formal technical violation, on average, by 66%, compared to those who did not have an ignition-interlock probation condition (Table 14). However, this measure has a 95% confidence interval of 1.11 to 2.52. This wide range indicates a large variation in the effect of the ignition-interlock device on the likelihood of a technical probation violation. The confidence interval for the likelihood of a new offense spans 1. This means there is the same risk of none of the individuals experiencing a new offense as those with the ignition-interlock device having a greater or lesser likelihood of this probation violation.

Table 14. Cox Regression for Probation Compliance

Treatment group	Violation	Hazard Ratio	95% CI
Probation:	Technical	1.66	1.11-2.52
	New Offense	.96	.66-1.41

Note. CI = Confidence Interval

Technical violations include a variety of types of non-legal, non-compliance but do not include ignition-interlock device, non-compliance. Non-compliance with the

ignition-interlock device often involves failure to have the vehicle serviced according to the monthly schedule, or providing a breath sample with alcohol. Alcohol consumption is often prohibited, in conjunction with the use of the device, as a condition of pretrial bond or probation sentence. Given that this non-compliance was not included in the data used for this study, the increased likelihood of a technical violation indicated that the restrictions placed by this device affected the compliance with other, unrelated conditions.

Matched Logistic vs. Multivariate Logistic

The differences and similarities between propensity score matching and alternative methods of control for confounding variables were assessed using bivariate and multivariate logistic regression analysis. The outcome of interest for both types of analysis is DWI recidivism over the entire observation time period in relation to receiving one of the three treatments. To compare the estimates using both of the control techniques, similar samples were constructed. A random sample was selected from the larger, total group of comparison cases, equal in size to each of the matched sample's comparison group. This resulted in two samples, equal in size, one constructed using propensity score matching, and one sample with the same treatment cases but randomly selected comparison cases. STATA's *sample* command was used to construct the random sample.

For the matched samples, a bivariate logistic regression was conducted to estimate the ignition-interlock device's effects on the occurrence of DWI recidivism. The multivariate logistic regression model included the same variables used in each matching sample's optimal matching model as controls (Table 3 in Chapter 5).

Tables 15, 16 and 17 report the logistic regression results for both models for each post-arrest treatment. The matched sample and unmatched random sample represent the likelihood of DWI recidivism over different observation time periods. Both of these models produced negative average treatment effects of the ignition-interlock device on DWI recidivism (Table 15). The regression models produced results indicating a reduction in the likelihood of DWI recidivism 95% of the time during these time periods, while the device was installed and up to one year after device removal. Across time periods, the regression coefficients, while in the same direction, differ in magnitude. For example, the regression using the matched sample indicates that when the interlock is used during the pretrial phase, there is a 4% reduction in the likelihood of DWI recidivism. Comparatively, the regression using the random sampled comparison group indicates that when the interlock was used there was a 5% reduction in the likelihood of DWI recidivism, during this same time period (Table 15). Confidence intervals for both the matched and unmatched time periods exist relatively close to zero indicating a small effect size. The confidence interval for the matched sample is smaller than that for the unmatched indicating the measure is more precise.

The unmatched random multivariate regression model produces wider confidence interval estimates of average treatment effects than the matched bivariate model. These CIs across each treatment span zero indicating these estimates of the ignition-interlock device's effects using an unmatched sample may be negligible. The difference in these results to those of the matched sample indicates that the matched sample produced more conservative estimates in effect size than the multivariate logistic regression results using a random sample.

Table 15. Logistic Regression Results for Pretrial Treatment

	Time Period	*b*	CI
Matched Sample (bivariate):	Install	-.04	(-.07, -.003)
	Uninstall Probation term	-.03	(-.08, .03)
	Install/Uninstall to Short-term	-.05	(-.12, .02)
	Install/Uninstall to Long-term	-.03	(-.11, .06)
	Uninstall to Short-term	-.01	(-.07, .05)
	Uninstall to Long-term	.01	(-.09, .11)
n = 312			
Unmatched random sample (multivariate):	Install	-.05	(-.09, -.01)
	Uninstall Probation term	-.01	(-.08, .07)
	Install/Uninstall to Short-term	-.06	(-.16, .04)
	Install/Uninstall to Long-term	.01	(-.11, .12)
	Uninstall to Short-term	-.01	(-.10, .08)
n= 312	Uninstall to Long-term	.05	(-.06, .17)

Note. CI = Confidence Interval. Install is the time period the device is installed or ordered to be installed. Install/Uninstall to short-term is from the time the device is installed or ordered to be installed to one year after the device order has expired. Install/Uninstall to long-term is from the time the device is installed or ordered to be installed to up to six years after the device order has expired. Uninstall to short-term is one year after the device order has expired. Uninstall to long-term is up to six years after the device order has expired.

The probation treatment, logistic regression results, shown in Table 16, for both matched and unmatched random samples indicate no influence of the ignition-interlock device on recidivism beyond chance. The only average treatment effects comparable across samples were for while the device was installed and one year after device removal (Table 16). These regression coefficients are in the same direction across both matched and unmatched samples and the confidence intervals do not cross zero or one. For example, the matched and random sample regression results indicate a negative effect of

the interlock device on DWI recidivism from installation to one year after device removal. The matched sample produced a coefficient of -.03 (95% CI [-.07, -.003]) and the random sample of -.05 (95% CI [-.10, -.02]) (Table 16). Both matched and random sampled logistic regression models do produce similar negative effect of the interlock device, on DWI recidivism, while the device is installed (-.03) (Table 16). The confidence intervals for the estimates using the matched sample are also narrower than the unmatched sample. Overall, the matched sample regression model produces more conservative and more precise estimates of the ignition-interlock device's effects than the randomly sampled, multivariate regression model.

Table 16. Logistic Regression Results for Probation Treatment

	Time Period	*b*	CI
Matched Sample (bivariate):	Install (Probation Term)	-.03	(-.05, -.001)
	Install/Uninstall to Short-term	-.03	(-.07, -.003)
	Install/Uninstall to Long-term	-.04	(-.08, -.01)
	Uninstall to Short-term	-.01	(-.03, .01)
	Uninstall to Long-term	-.02	(-.04, .01)
n = 1,284			
Unmatched random sample (multivariate):	Install (Probation Term)	-.03	(-.06, -.01)
	Install/Uninstall to Short-term	-.05	(-.07, -.02)
	Install/Uninstall to Long-term	-.06	(-.10, -.02)
	Uninstall to Short-term	-.02	(-.03, .01)
	Uninstall to Long-term	-.02	(-.06, .01)
n = 1,284			

Note. CI = Confidence Interval. Install is the time period the device is installed or ordered to be installed. Install/Uninstall to short-term is from the time the device is installed or ordered to be installed to one year after the device order has expired. Install/Uninstall to long-term is from the time the device is installed or ordered to be installed to up to six years after the device order has expired. Uninstall to short-term is one year after the device order has expired. Uninstall to long-term is up to six years after the device order has expired.

The matched sample bivariate regression model for the combined pretrial and probation treatment sample produced results indicating a likely reduction in DWI recidivism while the device is installed and one year after device removal. The random sample, multivariate regression model produced estimates of negative average treatment effects also for those who had the ignition-interlock device installed after arrest, to the probation sentence termination, and one year after device removal. On average, those who received the combined pretrial and probation treatment had a decreased likelihood of DWI recidivism between five and seven percent over these time periods for the matched sample, seven and eight percent for the unmatched (Table 17). Similar to the other matched and unmatched sample comparisons, the confidence intervals are narrower for the matched sample than the unmatched. These intervals are also closer to zero indicating that the matched sample produces stronger and more precise estimates of the device's effects.

Table 17. Logistic Regression Results for Pretrial and Probation Treatment

	Time Period	*b*	CI
Matched	Install	-.05	(-.08, -.01)
Sample (bivariate):	Install/Uninstall to Short-term	-.07	(-.10, -.01)
	Install/Uninstall to Long-term	-.06	(-.11, .02)
	Uninstall to Short-term	-.02	(-.04, .02)
	Uninstall to Long-term	-.01	(-.06, .04)
Unmatched	Install	-.07	(-.13, -.003)
random sample (multivariate):	Install/Uninstall to Short-term	-.08	(-.16, -.01)
	Install/Uninstall to Long-term	-.02	(-.08, .05)
	Uninstall to Short-term	-.02	(-.06, .03)
	Uninstall to Long-term	-.02	(-.08, .05)

Note. CI = Confidence Interval. Install is the time period the device is installed or ordered to be installed. Install/Uninstall to short-term is from the time the device is installed or ordered to be installed to one year after the device order has expired. Install/Uninstall to long-term is from the time the device is installed or ordered to be installed to up to six years after the device order has expired. Uninstall to short-term is one year after the device order has expired. Uninstall to long-term is up to six years after the device order has expired.

Overall, the differences in effect sizes of each logistic regression comparison were fairly small. The size of the difference, however, is secondary in importance to the difference between estimates in the first place. Multivariate control techniques may contain selection bias because the control variables introduced to the model are also likely to maintain some level of selection bias (Heckman, 1979). The differences found in this logistic comparison likely represent this additional selection bias that is not present in the matched sample.

The multivariate regression on the unmatched sample's relative effects were slight. For comprehensive reporting of these models the odds ratios for each multivariate regression model for each treatment type are reported for both the installed and installed to one year after device removal time periods. The relative effects for these specific time periods are reported because the treatments' effects were likely beyond chance in the population across either two or all three of the types of treatment.

Table 18 reports the odds ratios of the full multivariate regression model. The treatment effect is greater than or equal to all of the relative effects across each type of treatment (Table 18). This treatment effect ranges from a decrease in the odds of DWI recidivism by a factor of .93 to .97. Majority of the other relative effects, while the device was installed, were not likely beyond chance except for age and gender for the probation treatment model. For these control variables, change in the odds of DWI recidivism, while controlling for the other effects in the model, were also slight. An increase in age resulted in a decrease in the odds of DWI recidivism by a factor of .99 and for gender, being male resulted in a decrease in the odds of DWI recidivism by a factor of .97 compared to being female (Table 18).

Table 18. Multivariate logistic regression while the device is installed

	Pretrial		Probation		Pretrial and Probation	
	OR	CI	OR	CI	OR	CI
Interlock Treatment	.95	(-.09, -.01)	.97	(-.06, -.01)	.93	(-.13, -.003)
Age	.99	(-.003, .001)	.99	(-.003,-.001)	.99	(-.004, .002)
Gender	1.01	(-.03, .05)	.97	(-.05, -.002)	.99	(-.08, .05)
Employment	.99	(-.02, .02)	.99	(-.003, .02)	1.01	(-.02, .04)
Race	.99	(-.03, .02)	-	-	-	-
Total risk level	-	-	.99	(.003, .04)	1.02	(-.03, .06)
Prior felony conviction	.99	(-.05, .03)	1.02	(-.04, .03)	1.03	(-.04, .11)
Number of prior DWI's	.99	(-.04, .02)	.99	(-.03, .01)	1.01	(-.04, .06)
Alcohol treatment ordered during bonding	1.04	(-.004, .08)	1.02	(-.01, .04)	-	-
Supervision ordered during bonding	.99	(-.08, .06)	-	-	-	-

Note. OR = Odds Ratio. CI = Confidence interval. Dashes (-) represent exclusion from the multivariate logistic regression model.

Table 19 reports the treatment and relative effects from the multivariate logistic regression. The models for both the probation and combined pretrial and probation treatment are reported in Table 19.

Table 19. Multivariate logistic regression while the device is installed to one year after removal

	Probation		Pretrial and Probation	
	OR	CI	OR	CI
Interlock Treatment	.95	(-.07, -.02)	.92	(-.16, -.01)
Age	.99	(-.004, -.001)	.99	(-.005, .001)
Gender	.94	(-.09, -.02)	.98	(-.10, .05)
Employment	.99	(-.02, .01)	1.01	(-.02, .05)
Risk	1.02	(-.01, .04)	1.04	(-.01, .09)
Prior felony conviction	.99	(-.05, .04)	.99	(-.09, .09)
Number of prior DWI's	.99	(-.04, .02)	1.00	(-.05, .06)
Alcohol treatment ordered during bonding	1.04	(.003, .07)	-	-

Note. OR = Odds Ratio. CI = Confidence interval. Dashes (-) represent exclusion from the multivariate logistic regression model.

The relative effects on DWI recidivism from the time the device is installed to one year after removal are also slight. Majority of these effects are not likely beyond chance in the population with the exception of age and gender for the probation interlock treatment multivariate regression model. An increase in age decreases the odds of DWI recidivism occurring by a factor of .99 and being male also decreases the odds of DWI recidivism by a factor of .94. The relative effects in the combined pretrial and probation regression model's relative effects were not likely beyond chance.

Overall, the relative effects on the odds of DWI recidivism were fairly weak across all observation time periods. Among these effects the strongest were of age and gender. Although these specific effects were likely beyond chance in the population they were not stronger than the treatment effects. This indicates that receipt of one of the three types of post-arrest ignition-interlock treatments influences the occurrence of DWI recidivism more than these alternative predictors. Although characteristics such as age and gender influence the likelihood of DWI recidivism this influence is not as great as receiving the ignition-interlock device as a condition of bond or probation.

Treatment as an Interaction

An alternative way to consider the combined pretrial and probation ignition-interlock device treatment is as an interaction. Instead of viewing this treatment as its own individual type of imposition of the ignition-interlock device, it could represent the interaction of the pretrial and probation treatments when both are imposed. To address this inquiry a supplemental analysis was conducted using Cox regression. A matched sample was constructed on the likelihood of receiving the ignition-interlock device

during any of the post-arrest phases. The matched comparison cases are DWI offenders from the larger, comprehensive sample who never had the ignition-interlock device.

The matching procedure was identical to what was used to construct the three matched treatment samples, as well as, the same criteria for an optimal matching model. The final matched sample included all of the matching variables in the optimal matching model for each of the other three matched treatment samples. This includes age, gender, employment, race, risk, prior felony convictions, prior number of DWI's, receiving alcohol treatment, and being supervised during bond. All significant differences across the sample were balanced as a result of the matching procedure. The final sample size was 1,796, including 898 total treatment and 898 comparison cases. This matching procedure resulted a loss of 186 cases as a result of failed matched. This large number of failed matches is likely due to aggregation of the treatment variable from individual post-arrest phases to interlock received at all, altering the differences across the treatment and comparison groups.

The treatment cases were coded according to imposition of the device during the pretrial and the probation phases. This differs from how this is measured in the primary analysis because the categories are not mutually exclusive. For this analysis, those who use the ignition-interlock device during the pretrial phase and the probation phase are counted in both categories (Table 20). For example, an individual who had the device only during the probation phase is included only in the probation interlock category. However, an offender who had the device during both the pretrial and probation phases is counted in all three categories (Table 20). The variables are redefined in this manner to allow for the calculation of an interaction effect because if the

categories were mutually exclusive they would cancel out.

Table 20. Treatment Variables for Supplement Analysis

	Pretrial Phase	Probation Phase	Interaction
Pretrial Interlock	1	0	0
Probation Interlock	0	1	0
Interaction	1	1	1
Comparison	0	0	0

Two Cox regression analyses were conducted. Cox regression was most appropriate because the observation time periods varied for each case in the sample. The first analysis was of the main effects of the ignition-interlock device during the pretrial or probation phase. The second analysis was of the interaction effect controlling for these main effects. Both regression models had a dichotomous, dependent variable representing DWI recidivism occurring during the observation time period.

The first model of the main effects produced results likely to occur beyond chance for both post-arrest phases. The average risk of DWI recidivism was 43% lower for those who had the device during the pretrial phase, while controlling for the effect of having the device during the probation phase. The ignition-interlock device used during the probation phase will, on average, result in a 44% lower risk of DWI recidivism while controlling for the effect of having it during the pretrial phase (Table 21).

Table 21. Main Effects of the Ignition-Interlock Device on DWI Recidivism

	Hazard Ratio	CI
Pretrial Interlock	.57	(.39, .83)
Probation Interlock	.56	(.43, .72)

Note. CI = Confidence Interval

The second Cox regression model includes the main effects and the interaction of the use of the device across phases. Table 22 reports that the main effects of the ignition-interlock device when used during either the pretrial or probation phases are still

more likely than chance; however, the interaction's effect when the device is imposed during both post-arrest phases is not. The effect of pretrial interlock treatment while controlling for probation treatment is .44 with a 95% confidence interval of .27 to .74 (Table 22). This means that there is a 95% chance that the use of this device during pretrial reduces the risk of DWI recidivism by at least 26%. During the probation phase there is at least a 32% reduction in the risk of DWI recidivism. Both of these estimates are, on average and while controlling for the effect of either phase.

Table 22. Interaction Effects of the Ignition-Interlock Device on Recidivism

	Hazard Ratio	CI
Interaction	1.92	(.90, 2.40)
Pretrial Interlock	.44	(.27, .74)
Probation Interlock	.51	(.39, .68)

Note. CI = Confidence Interval

The interaction effect is not likely to occur beyond chance in the population (Table 22). Having an ignition-interlock device during both post-arrest phases does not decrease the risk of DWI recidivism any more than having it during either phase. The pretrial and probation treatment analysis using the matched sample produced some non-negligible effect estimates. This indicates that measuring these ignition-interlock treatments in these manners is not the same.

These results differ from results in the primary analysis because they address different questions. The primary analysis defining each post-arrest treatment as mutually exclusive addresses the effectiveness of the ignition-interlock device for those most likely to receive that treatment. The supplemental analysis defining the treatments as interactive addresses the effectiveness of the ignition-interlock device for those most likely to receive the device, regardless of post-arrest phase. This is a difference in specificity of counterfactuals leading to removal of less imbalance between groups,

resulting in different estimates.

VII. CONCLUSIONS

The negative consequences of DWI make it an important criminal justice and public safety issue. The consequences often involve a host of responses, such as license suspension, incarceration, alcohol treatment, and/or alcohol-monitoring technology. The ignition-interlock device is one of the most common corrective methods for DWI offenders used during different post-arrest phases (National Traffic Highway Safety Administration, 2010). There has been extensive study of the use of this device during only the probation, post-arrest phase, yet little is known about its use during the pretrial phase. This study focuses on the use of the device during the pretrial, probation and combined pretrial and probation phases. The assessment of the ignition-interlock device's effects includes two elements of recidivism: risk to, and the time to re-offend on DWI offenders and serious DWI offenders of intoxication assault and manslaughter. This is an extended measure of DWI recidivism compared to prior study that includes intoxication assault and manslaughter.

Risk of DWI Recidivism

With regard to the first research question: *Does the ignition-interlock device reduce a DWI offender's likelihood to commit a subsequent DWI?,* decreases in the likelihood of DWI recidivism were found during the time the device was installed, and one year, as well as, up to six years after the device was removed. Assessment of the ignition-interlock device's effects while it was installed produced the strongest and most consistent findings across all three matched samples, estimating a 45% to 90% DWI recidivism-risk reduction. In absolute terms, this risk reduction is actually an additional 6

to 27 DWI recidivism events for those who do not use the ignition-interlock device. Applying the confidence intervals to this interpretation reveals that there is a reduction in the risk of DWI recidivism beyond a 95% chance, however this risk reduction could be as low as 1% to 13%. This finding is consistent with findings from previous studies, that, while installed, the device is effective but once removed, problem drinking and driving behavior quickly return to previous patterns (EMT Group, 1990; Voas, Blackman, Tippetts, & Marques, 2002; Morse & Elliot, 1992; Raub, Lucke, & Wark, 2003; Roth et al., 2005; Voas, Blackman, Tippetts, & Marques, 2002). Although slight, these consistent findings indicate that the ignition-interlock device successfully meets its intended goal of preventing individuals who have received a DWI from subsequent driving under the influence of alcohol while in place on the vehicle.

Looking beyond the installation time period, lasting effects from the device after it was removed were also found for those who used the device during the probation and the combined pretrial and probation, post-arrest phases. The effect of the ignition-interlock device when used during the pretrial phase was only likely to occur beyond chance when the device was installed. From installation to up to six years after device removal, use of the device during probation reduced the likelihood of DWI recidivism from 36% to 65% and device use during both pretrial and probation phases reduced DWI recidivism from 28% to 48%. This corresponds to an additional 17 to 26 DWI recidivism events for the probation treatment comparison group and 9 to 15 more DWI recidivism events for the combined pretrial and probation treatment comparison group. These confidence intervals also indicate the effect in the population could be as small as 7% to 13%. The lasting effect of the ignition-interlock device may be likely for these types of

treatments but are slight. Furthermore, this is a slight change in an already high probability of not committing a subsequent DWI or non-alcohol related offense.

The finding of a reduction in the likelihood of DWI recidivism after the device was removed diverges from previous studies of the ignition-interlock device's effects (Willis, Lybrand & Bellamy, 2004; Elder et al., 2011). The present findings are consistent with two of the more recent studies that used an experimental design to examine the influence of the ignition-interlock device on recidivism. Beck et al. (1999) found a 32% reduction in the risk of DWI recidivism from when the device was installed to one year after removal, and Rauch et al. (2010) found a 26% reduction in DWI recidivism up to two years after device removal. The consistency of this study's findings with these previous random control studies provides greater support for use of more robust methodology to assess the effects of the ignition-interlock device. Propensity score matching does not serve as a replacement for experimental design, it should be considered an appropriate approach in the absence of this gold standard.

The moderate to strong effects on DWI recidivism found while the device was installed supports the presence of an incapacitation effect. The interlock device used during the pretrial phase only reduced the likelihood of DWI recidivism while it was installed. In contrast, the lasting effects of the ignition-interlock device when used during the probation and combined pretrial and probation phases support both an incapacitation effect, as well as, a possible deterrent effect. This could also represent an interaction effect in that the monitoring of the device during pre- and post-conviction increased the effectiveness of the ignition-interlock device. When this interaction was tested it was found to have no influence beyond chance, however this estimate could still contain bias

due to unobserved confounding effects.

Interestingly, the combined pretrial and probation matched treatment sample have the highest average criminal risk level, as well as, the strongest lasting effect of the ignition-interlock device on DWI recidivism, after the device was removed. This suggests that for those who are most likely to receive the ignition-interlock device, because they are considered to be the greatest risk for DWI recidivism, receive the greatest benefit from its use, compared to those most likely to receive it during only one post-arrest phase. Ultimately, this device is most effective as an incapacitating, and possibly deterrent method for those likely to use it the longest.

Time to DWI recidivism

To answer the second research question: *Does the imposition of the ignition-interlock device reduce the time when a DWI offender is likely to re-offend?,* survival analysis was performed. The findings showed that while the device was installed, for one year, and up to six years after removal, there was a delay in the average time to DWI re-offending. By the end of the installation time period, for both the pretrial and combined pretrial and probation matched treatment sample, these comparison groups had a 15% lower probability of survival and the probation group a 10% lower probability of survival. Those who had the interlock device installed, during any post-arrest phase, were slower to recidivate compared to those who did not use the ignition-interlock device. This supports the hypotheses that those with the interlock device will take a longer time to commit a subsequent DWI for offenders likely to receive any one of these three interlock treatments.

A lasting delay in DWI recidivism from installation to after the device was removed, for one year, and up to six years, were found for those receiving the ignition-interlock device during the probation and the combined pretrial and probation, post-arrest phases. The difference between the treatment and comparison groups' survival probabilities increases after the average probation termination and device removal for the treatment groups. Comparison of these matched groups revealed that the changes in one's pattern of problem drinking and driving, because of the use of the ignition-interlock device, continued after the device was no longer in use. These lasting effects support both an incapacitation effect, as well as, a deterrent effect.

Interestingly, the pretrial treatment only delayed the probability of DWI recidivism while the device was installed, likely as a result of incapacitation. Compared to those who have the device during the probation or pretrial and probation post-arrest phases, the pretrial interlock treatment ends at the beginning of a person's probation sentence, while still under supervision. Being required to begin or continue use of this device, post-conviction, may serve as a contributing factor to additional delay in DWI recidivism, after device removal.

Non-alcohol Recidivism

To answer the third research question: *Does use of the ignition-interlock device affect non-alcohol recidivism?*, both the risk to and time to non-alcohol recidivism, non-alcohol recidivism being all non-alcohol related offenses, were assessed. The effects of the ignition-interlock device on non-DWI recidivism, both the risk of and time to, were largely unlikely in the population beyond random chance. The only treatment that resulted in significant reductions in either the risk to or time to re-offending was the

combined pretrial and probation interlock treatment. The ignition-interlock device did not affect non-alcohol recidivism when imposed during either one of the pretrial or probation phases. A reduced likelihood of non-alcohol recidivism was found while the device was installed during both the pretrial and probation phases, and up to six years after device removal. There is a 46% reduction in the risk of non-alcohol recidivism from installation to one year after device removal and a 38% reduction in the risk of non-alcohol recidivism up to six years after the device is no longer in use.

Delay in non-alcohol recidivism because of the ignition-interlock device was only found for those who used the device during both the pretrial and probation post-arrest phases. A likely probability of not having a non-alcohol recidivism event, beyond chance, were found for this treatment only when the device was installed and one year after device removal. This indicates that the interlock device, as a legal control, may have an effect on non-alcohol recidivism, when used over the entire duration of the DWI offender's criminal justice intervention. Stronger and more consistent effects on DWI recidivism indicate that although this control may influence criminality in the short-term, its effect on problem drinking and driving are greater.

Probation Compliance

To answer the fourth research question: *Does imposition of the ignition-interlock device increase a DWI offender's likelihood of compliance with probation conditions?*, Cox regression was performed. The hypothesis that it increases the likelihood of non-compliance is supported for technical violations of probation but not for new offenses. Those who had the ignition-interlock device during the probation, post-arrest phase were 66% more likely to commit a technical violation while on probation, compared to those

who did not use the device. Comparatively, there was no effect of the ignition-interlock device on probation non-compliance as a result of committing a new offense.

Those required to use the interlock device were required to maintain the device including paying interlock fees, and having it serviced monthly. Furthermore, the ignition-interlock device provides more opportunity for an offender to be non-compliant possibly leading to more attention from the monitoring authority. These requirements were often in addition to completing community service hours, attending regular probation office visits, and completing counseling requirements. Finding only a significant effect of the interlock device on technical but not offending violations, both DWI and non-alcohol related offenses, indicates that the constraints imposed by the device presents a greater non-legal than legal challenge.

Comparison of Approaches

To answer the fifth research question: *Does matching according to characteristics relevant to the imposition of the ignition-interlock device produce different effects than a multivariate regression analysis that seeks to statistically control for selection bias?*, comparable samples were constructed, one using a matching technique and one a random sample. Logistic regression models to estimate the ignition-interlock device's effect on the likelihood of DWI recidivism occurring at all are used and the results were compared. The ignition-interlock device was found to significantly reduce the likelihood of DWI recidivism, while the device was installed and one year after device removal. Results of both logistic regression model were negative indicating that the ignition-interlock device reduced the likelihood of DWI recidivism for both the matched and random sample.

Although both models controlled for the differences between treatment and comparison groups with the same confounding variables, the results differed in effect size. The corresponding confidence intervals to these effects sizes are relatively close to zero indicating the effects to be fairly negligible in the population. However, these confidence intervals that indicate this effect is small do also differ across the matched and unmatched samples. The matched sample produced conservative results, closer to zero, compared to the random sample. This confirms the hypothesis that these techniques produce different effects. This does not mean that one technique is necessarily more useful for observational studies, but it does suggest that these approaches to controlling for selection bias are not the same.

The larger question, why do these results differ from techniques, which largely do the same thing? Heckman (1979) argued that remaining selection bias in results using multivariate control techniques are not because of a failure to remove bias from confounding variables but rather because additional bias may be introduced from control variables. Propensity score matching is advantageous because it does not contain the potential for producing inflated estimates. Constructing matched samples eliminates differences between the treatment and comparison groups prior to the analysis, reducing the risk of over- or under-controlling for these differences (Guo & Fraser, 2010).

Spuriousness may still be present in the model due to unmeasured counterfactuals not accounted for in the matching procedure. Propensity score matching does reduce the likelihood of biased estimates by accounting for known confounding variables, however it cannot control for the unknown in the manner that random assignment can. Considering this advantage of propensity score matching and

Heckman's work on selection bias, it is defensible to conclude that the differences in magnitude found in this comparison are likely due to additional selection bias introduced from the control variables.

Overall, the assessment of this technique within the context of the ignition-interlock device reveals that more research on the value of matching techniques is necessary. Results indicate that propensity score matching will likely produce different results from traditional multivariate techniques, but ultimately, do these differences matter? The more conservative estimates produced by the matching are more desirable simply because they carry less of a potential for over-estimation of an effect. The true answer likely to the value of either technique lies in why these methods in fact produce different values and what method is most appropriate under certain conditions.

The purpose of doing this study is to assess how the use of this alternative control technique estimates the well-studied effect of the ignition-interlock device. Difference, although slight, is found between the estimates using these techniques. This confirms what is already known about propensity score matching under another set of conditions within the context of DWI recidivism. Continued test of these techniques under different data conditions will further the understanding of when either method of control should be used.

Limitations

A notable limitation of this study is the use of official records to measure offending. DWI offending carries a low probability of detection; thus official data provide only insight into those offenses that result in an arrest. The data are also limited in providing information to draw inferences about possible deterrent effects of the

ignition-interlock device. The lasting effect of the ignition-interlock device after it has been removed could represent a deterrent effect. The official data for this study do not provide insight into the rational processing of the DWI offender prior to engaging in any type of recidivism. Direct inference about the ignition-interlock device's effects can only be made about the incapacitating effect of the device.

Arguably, this study is also limited by its focus on the use of the ignition-interlock device in a single jurisdiction. The imposition of the interlock device during any post-arrest phase differs among jurisdictions. Factors, such as agency supervisory protocol, officer discretion, and level of oversight of offenders, may all play a role in the estimates produced from this jurisdiction. Examination of the use of the ignition-interlock device across different monitoring agencies, pretrial services and adult probation, mitigates this limitation, but to fully eliminate it, the ignition-interlock device's use should be assessed in multiple jurisdictions.

Failure to install is a related limitation to agency oversight. In a recent national evaluation of ignition-interlock programs, failure to install the device was found to be a consistent obstacle, across programs. Of the 28 states evaluated only three states had ignition-interlock program monitoring protocol that ensured installation of the device (Casanova-Powell, Hedlund, Leaf & Tison, 2015). The data for this study are limited in confirming installation of the ignition-interlock device during the probation phase because date of installation order is used to define this treatment. This limitation provides the potential to under-estimate the device's effect because those recidivists who received the order but never installed are miscounted.

Policy Implications and Future Study

This study's findings provide support for the NHTSA's recommendations for the expansion of the use of the ignition-interlock device. These findings support not only the NHSTA's recommendation for expansion of who uses the device; it also suggests expansion in how long this device is to be used for those DWI offenders who are ordered to have it. Ignition-interlock program policy can be refined and improved if those who are thought to be in need of this device, in order to mitigate the consequences of DWI recidivism, are required to have the device during longer periods of time. It is well supported in this study and prior literature that the ignition-interlock device reduces the occurrence of DWI recidivism while in use.

It is also well supported in this study that the device may provide some lasting effects after it is no longer in use. It is clear that the device reduces DWI recidivism while it is in use and for some time after, depending on who the offender is and their likelihood to engage in DWI recidivism. Ignition-interlock policy aimed to require those who need the device the most to use it for a longer period carries important implications for public safety of roadways. Furthermore, compliance or non-compliance and the receipt of alcohol treatment while using the device predict recidivism following removal of the device (Voas, 2015). Future study should examine compliance with the ignition-interlock device to provide even better prediction of a DWI offender's likelihood to re-offend. The ignition-interlock device used in conjunction with alcohol treatment may also enhance its effect of DWI recidivism risk.

To address some of the study limitations and further inform ignition-interlock policy, future study should be conducted in multiple jurisdictions that impose this device

on DWI offenders. Jurisdictions with a variety of environmental factors that may lead to differences in likelihood of detection, such as, access to public transportation, the average number of miles driven, or vehicle density on roadways would provide a better understanding how well DWI offending is measured by official arrest data. Furthermore, a multi-jurisdiction study of the interlock device's effects on DWI recidivism would be advantageous because differences in agency approaches to enforcing and monitoring use of the device could be taken into account.

To understand the value of the ignition-interlock device used during one post-arrest phase compared to another, future studies should employ a different type of propensity score matching. The current study compared the use of the device during one post-arrest phase to non-use. Matching across treatment types allows for inferences about the effectiveness of one treatment versus another, for similar offenders. For example, matching those who received the interlock device as a condition of pretrial release to those who received it during both pretrial and probation post-arrest phases constructs a sample of similar offenders. This allows for the assessment of average treatment effects for both types of treatment and which one is more effective at reducing the risk of DWI recidivism, as well as, the time to DWI recidivism.

In conclusion, this assessment of the ignition-interlock device indicates there are effects on recidivism when this device is used. Making this assessment by comparing treatment and comparison groups similar in the likelihood of re-offending and receiving the ignition-interlock device provides for reliable estimates of the device's average treatment effects. Results from this study inform both existing policy, as well as, the effects of the ignition-interlock device when used during all post-arrest phases. Future

assessment of the device's effects in different jurisdictions and matching according to treatment types will further inform and improve how the ignition-interlock device is used to reduce DWI recidivism and increase public safety on roadways.

APPENDIX SECTION

APPENDIX A: CODEBOOKS

Travis County Probation Codebook

Variable Name	Purpose	Description
SID	merging datasets	State identifying number
race	matching	African American Asian or Pacific Native American or Alaskan Native Caucasian Other
ethnicity	matching	Hispanic Non-Hispanic
gender	matching	female male
marital status	matching	D- divorced M- married P- separated S- single U- unknown W- widow
dependent	matching	number of dependents
age	merging	individual age at time of arrest
employment status	matching	1- full-time 2- part-time 3- seasonal 4- student/retired/homemaker/ disabled 5- unemployed
probation date	calculate recidivism follow-up time period	probation start date for Travis County
sentence	calculate recidivism follow-up time period and survival analysis	length of sentence
extend probation term	calculate recidivism follow-up time period	sentence extended to this date
charging code	matching	legal code for offense
charge	matching	language of the offense
degree	matching	F- felony unclassed

Variable Name	Purpose	Description
		F1- felony level one F2- felony level two F3- felony level three M- misdemeanor unclassed MA- misdemeanor level A MB- misdemeanor level B
unit	matching (identifying absconders)	unit code ABS- absconder ADM- administrative CT- court DIAG- diagnostic INTA- intake N1- north 1 N2- north 2 N3- north 3 S1- south 1 S2- south 2 S3- south 3 S4- south 4 S5- south 5 SMT- Smart Unit SPC1- specialized mental health SPC2- specialized sexual offenses SPC3- specialized substance offenses
supervision status	matching	supervision status 2- maximum 3- medium 4- minimum R- SMART facility TO- transfer out county TOS- transfer out state A- absconder ICJ- incarcerated in jail IID- incarcerated in prison M- reporting by mail D- offender deported O- offenders date of discharge passed/other reason PTD- pretrial diversion
violation report	outcome variable	most recent supervision

Variable Name	Purpose	Description
		status change
violation date	outcome variable	date most recent violation report was sent
motion to revoke probation summary	outcome variable	outcome of violation report MTR-arrested MTR/MTA Issued-summons MTR/MTA Issued- no war MTR/MTA Issued- war
violation count	outcome variable	number of probation violations
violation result	outcome variable	results of violation report
violation result date	outcome variable	date of the most recent violation report result
termination date	outcome variable	date terminate
termination reason	outcome variable	reason terminated AM- adjudicated probated by defendants motion AR- adjudicated and probated by motion to revoke CP- competed probation CS- completed sentence DT- death ED- early discharge OA- other administrative closures RV- revocation and sentenced to incarceration VC- violations of conditions
revocation reason	outcome variable	reason for revocation O- other OA- failure to appear OB- failure to pay OC- absconder OD- positive UA OE- treatment non-participation NO- new offense SM- new offense
revocation for subsequent offense level	outcome variable and matching	if revoked for subsequent offense F- felony

Variable Name	Purpose	Description
		M- misdemeanor
last date of supervision	identify absconders	date of last face to face contact with probationer
last date of administration hearing	identify absconders	date officer last heard from probationer
last date of contact	identify absconders	date of last contact with probationer
number of administrative hearings	outcome variable	number of administrative hearings
number of supervisory hearings	outcome variable	number of sup hearings
initial risk score	matching	initial risk score 0-7 minimum 8-14 medium 15+ maximum
initial risk indicator 1	matching	number of address changes in last 12 months 0- none 1-one 2- two or more
initial risk indicator 2	matching	percentage time employed in last 12 months 0- none 1- one 2- two or more
initial risk indicator 3	matching	alcohol usage 0- unrelated to criminal activity 1- probable relationship 2- definite relationship
initial risk indicator 4	matching	other drug usage 0- unrelated to charge 1- probable related to charge 2- definite relationship to charge
initial risk indicator 5	matching	attitude 0- motivated to change 3- somewhat motivated to change 5- not motivated to change
initial risk indicator 6	matching	age at first adjudication of guilt 0- 24 or older

Variable Name	Purpose	Description
		2- 20-23 4- 19 or younger
initial risk indicator 7	matching	number of prior periods of probation/parole 0- none 4- one or more
initial risk indicator 8	matching	number of prior probation/parole revocations 0- none 4- one or more
initial risk indicator 9	matching	number of prior felony adjudications of guilt 0- none 2- one 4- one or more
initial risk indicator 10	matching	adult or juv adjudications for… 0- none 2- burglary, theft, auto theft, or robbery 3- worthless checks or forgery
initial risk indicator 11	matching	adult or juv adjudicaitons for assaultive offense in last 5 years 0- no 8- yes
initial need score	matching	initial need score 0-14 minimum 15-29 medium 30+ maximum
initial need indicator 1	matching	academic/vocational skill -1- high school or above 0- adequate 2- low 4- minimal
initial need indicator 2	matching	employment -1- satisfactory 0- secure 3- unsatisfactory 6- unemployment
initial need indicator 3	matching	financial management -1- self-sufficiency

Variable Name	Purpose	Description
		0- no difficulties 3- minor difficulties 5- severe difficulties
initial need indicator 4	matching	marital/family relationships -1- relationship and support 0- relative stable 3- some disorganization 5- severe difficulties
initial need indicator 5	matching	companions -1- good support 0- no adverse 2- occasional negative 4- completely negative
initial need indicator 6	matching	emotional stability -2- exceptionally well adjusted 0- no symptoms 4- symptoms limit 7- symptoms prohibit
initial need indicator 7	matching	alcohol usage problems 0- no use 2- occasional abuse 6- frequent abuse
initial need indicator 8	matching	other drug usage problems 0- no use 3- occasional abuse 5- frequent abuse
initial need indicator 9	matching	mental ability 0- independent 3- some need 6- major need
initial need indicator 10	matching	health 0- sound health 1- some handicap/illness 2- serious handicap/illness
initial need indicator 11	matching	sexual behavior 0- no dysfunction 3- real or perceived minor problem 5- real or perceived chronic problems
initial need indicator 12	matching	PO impression of probationer needs -1- well adjusted

Variable Name	Purpose	Description
		0- no need 3- moderate need 5- high need
initial risk level	matching	initial risk level 4- minimum 3- medium 2- maximum
initial risk score adjusted	matching	captures if risk level is adjusted 4- minimum 3- medium 2- maximum
most recent risk score	matching	most recent risk score taken at the time of the snapshot
recent risk indicator 1	matching	number of address changes in last 12 months
recent risk indicator 2	matching	age at first adjudication of guilt
recent risk indicator 3	matching	number of prior probation/parole supervision revocations
recent risk indicator 4	matching	number of prior felony adjudications of guilt
recent risk indicator 5	matching	adult or juv adjudications for… 0- none 2- burglary, theft, auto theft, or robbery 3- worthless checks or forgery
recent risk indicator 6	matching	percentage of time employed
recent risk indicator 7	matching	alcohol usage 0- unrelated to criminal activity 1- probable relationship 2- definite relationship
recent risk indicator 8	matching	other drug usage 0- unrelated to charge 1- probable related to charge 2- definite relationship to charge
recent risk indicator 9	matching	problems with interpersonal

Variable Name	Purpose	Description
		relationship
recent risk indicator 10	matching	social identification
recent risk indicator 11	matching	response to court impose conditions
most recent need score	matching	most recent need score
most recent risk level	matching	most recent risk level
recent need indicator 1	matching	academic/vocational skill -1- high school or above 0- adequate 2- low 4- minimal
recent need indicator 2	matching	employment -1- satisfactory 0- secure 3- unsatisfactory 6- unemployment
recent need indicator 3	matching	financial management -1- self-sufficiency 0- no difficulties 3- minor difficulties 5- severe difficulties
recent need indicator 4	matching	marital/family relationships -1- relationship and support 0- relative stable 3- some disorganization 5- severe difficulties
recent need indicator 5	matching	companions -1- good support 0- no adverse 2- occasional negative 4- completely negative
recent need indicator 6	matching	emotional stability -2- exceptionally well adjusted 0- no symptoms 4- symptoms limit 7- symptoms prohibit
recent need indicator 7	matching	alcohol usage problems 0- no use 2- occasional abuse 6- frequent abuse
recent need indicator 8	matching	other drug usage problems 0- no use 3- occasional abuse

Variable Name	Purpose	Description
		5- frequent abuse
recent need indicator 9	matching	mental ability 0- independent 3- some need 6- major need
recent need indicator 10	matching	health 0- sound health 1- some handicap/illness 2- serious handicap/illness
recent need indicator 11	matching	sexual behavior 0- no dysfunction 3- real or perceived minor problem 5- real or perceived chronic problems
recent need indicator 12	matching	PO impression of probationer needs -1- well adjusted 0- no need 3- moderate need 5- high need
condition ordered	treatment variable	monitoring device ordered elm- electronic monitoring interlock- ignition interlock pam- portable breathalyzer SCRAM- transdermal alcohol sensor missing- no device ordered

Travis County Pretrial Services Codebook

Variable Name	Purpose	Description
pretrial identifier	merging	Identifier assigned by Pretrial Services
any condition ordered	treatment variable	whether bond conditions ordered Y/N
defendant placed on a caseload	treatment variable	assigned monitor over compliance
defendant supervised (required to report to pretrial services for office visits)	treatment variable	assigned to report to a pretrial officer
defendant ordered to install IID	treatment variable	Y/N

Variable Name	Purpose	Description
defendant ordered to attend TCCES Alcohol Evaluation	matching	ordered to attend counseling for substance abuse
defendant ordered to install SCRAM	treatment variable	Y/N
defendant ordered to install InHom	treatment variable	Y/N
bond granted	matching	whether release on bond was ordered Y/N
type of bond defendant released	matching	PR= personal bond CD= cash deposit SB= surety bond CA= cash bond
SID	merging	State identifying number
V23	treatment variable	12= IID 01C= TCCES Alcohol Evaluation 05= Supervision
number of conditions ordered	matching	total conditions ordered for bond release

Texas Department of Public Safety Codebook

Variable Name	Purpose	Description
SID	merging	State identifying number
offense name	outcome variable and matching	offense name
date of offense	outcome variable	date of arrest for subsequent offense
level of offense	outcome variable	Misdemeanor Felony
length of sentence	outcome variable	length of probation sentence

APPENDIX B: MATCHING VARIABLES

Matching Category	Variable Name
Offender demographic variables	age gender race ethnicity sex marital depend empstatus
Criminal risk and need level	total risk score total need score
Criminal history	prior number of felonies prior number of DWI arrests
Bond release conditions	alcohol treatment condition supervision type of release personal bond release

APPENDIX C: ROSENBUM'S SENSITIVITY ANALYSIS

	Gamma	**mh+**	**mh+ p-value**	**mh-**	**mh- p-value**
Pretrial Alcohol:	1	2.56	.005	2.56	.005
	2	.40	.34	5.95	1.3e-09
	3	2.26	.01	8.15	2.2e-16
	4	3.62	.000	9.86	0
	5	4.71	1.2e-16	11.29	0
	6	5.64	8.5e-09	12.55	0
	7	6.46	5.4e-11	13.69	0
	8	7.19	3.2e-13	14.73	0
	9	7.86	1.9e-15	15.69	0
	10	8.48	0	16.60	0
Pretrial Non-alcohol:	1	.64	.26	.64	.26
	2	1.79	.04	3.41	.000
	3	3.43	.000	5.16	1.2e-07
	4	4.66	1.6e-06	6.51	3.9e-11
	5	5.67	7.13-09	7.63	1.2e-14
	6	6.54	3.0e-11	8.61	0
	7	7.32	1.2e-13	9.49	0
	8	8.03	4.4e-16	10.30	0
	9	8.68	0	11.05	0

	Gamma	mh+	mh+ p-value	mh-	mh- p-value
	10	9.28	0	11.75	0
Probation Alcohol:	1	1.86	.03	1.86	.03
	2	4.05	.000	-.11	.54
	3	5.52	1.7e-08	.87	.19
	4	6.68	1.2e-11	1.69	.05
	5	7.68	7.9e-15	2.34	.01
	6	8.56	0	2.90	.002
	7	9.36	0	3.38	.000
	8	10.10	0	3.82	.000
	9	10.78	0	4.22	.000
	10	11.43	0	4.59	2.2e-06
Probation Non-alcohol:	1	.50	.31	.50	.31
	2	2.66	.004	1.26	.10
	3	4.04	.000	2.54	.01
	4	5.12	1.5e-07	3.50	.000
	5	6.02	8.8e-10	4.29	9.0e-06
	6	6.81	4.9e-12	4.97	3.3e-07
	7	7.52	2.8e-14	5.58	1.2e-08
	8	8.17	1.1e-16	6.13	4.3e-10
	9	8.77	0	6.64	1.5e-11
	10	9.34	0	7.12	5.4e-13

	Gamma	mh+	mh+ p-value	mh-	mh- p-value
Pretrial and Probation Alcohol:	1	1.57	.06	1.57	.06
	2	.76	.22	4.32	7.8e-06
	3	2.29	.01	6.09	5.6e-10
	4	3.43	.000	7.47	4.2e-14
	5	4.35	6.9e-06	8.61	0
	6	5.13	1.4e-07	9.63	0
	7	5.83	2.8e-09	10.54	0
	8	6.45	5.5e-11	11.37	0
	9	7.03	1.1e-12	12.15	0
	10	7.56	2.0e-14	12.88	0
Pretrial and Probation Non-alcohol:	1	1.65	.05	1.65	.05
	2	3.87	.000	.04	.48
	3	5.33	5.0e-08	1.22	.11
	4	6.48	4.7e-11	2.08	.02
	5	7.45	4.6e-14	2.77	.003
	6	8.31	0	3.36	.000
	7	9.09	0	3.88	.000
	8	9.81	0	4.34	7.0e-06
	9	10.47	0	4.77	9.2e-07
	10	11.10	0	5.17	1.2e-07

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