Published in final edited form as:
Accid Anal Prev. 2011 November ; 43(6): 1960–1967. doi:10.1016/j.aap.2011.05.014.

The Effects of Closer Monitoring on Driver Compliance with Interlock Restrictions

Paul L. Zador[a], **Eileen M. Ahlin**[a,b], **William J. Rauch**[a,c], **Jan M. Howard**[a], and **G. Doug Duncan**[a]

[a] Westat, 1600 Research Boulevard, Rockville, MD 20850, USA

1. Introduction

The alcohol ignition interlock is designed to prevent drivers from driving interlock-equipped vehicles when their blood alcohol content is at or above a designated threshold, typically .02 g/dL (Beirness and Marques, 2004; Willis et al., 2004). Drivers enrolled in an ignition interlock license restriction program are required to comply with a number of restrictions including: taking an initial breath test to measure alcohol content, providing rolling retests, driving with a breath alcohol concentration (BAC) below a preset limit, and not tampering with or bypassing the interlock device.[1] Monitoring drivers for compliance with these program requirements is a key, but often neglected, component of interlock programs. Non-compliance with these requirements may be an early indicator of future alcohol-impaired driving.]

Studies have shown that drivers who had fewer non-compliance events while participating in an interlock program were less likely to experience post-interlock recidivism from DUI (driving under the influence of alcohol) than were drivers who showed greater non-compliance with program requirements (e.g., Marques et al., 2001; Marques et al., 2003; Marques et al., 2010). Thus, Marques and colleagues (2003, pg 83) conclude that the proportion of failed interlock tests among all breath alcohol tests taken was the “best predictor of driver recidivism risk during the years following interlock removal.”

Results from studies in Canada (Marques et al., 1998, 1999, 2000) and Texas (Marques et al., 2004; Marques et al., 2007) indicate that interventions based on support services, case management, and motivational enhancement can increase compliance with the requirements of interlock programs. Moreover, researchers associated with a recent study financed by the Dutch Ministry of Transport contend that increases in compliance over time on the interlock were partially the consequence of ongoing monitoring (Vanlaar et al., 2010).

[b]Corresponding author: Eileen M. Ahlin, Ph.D., Westat, 1600 Research Boulevard, Rockville, MD 20850, USA, eileenahlin@westat.com, Phone: 1-301-294-4471, Fax: 1-301-610-5140.
[c]Present address: Association for Unmanned Vehicle Systems International (AUVSI), 2700 South Quincy Street, Suite 400, Arlington, VA 22206, USA

[3]Since we did not include the intercept, separate parameters estimated the effects of study-group assignment.

[1]For a comprehensive description of the interlock device from a historical, technological, and effectiveness perspective, see Beirness and Marques, 2004. Also see National Highway Traffic Safety Administration, 2010 for an updated discussion of model specifications for breath alcohol ignition interlock devices, and see the online technical report by Marques and Voas, 2010 that examines key features of ignition interlock programs.

This combination of findings (that increased compliance with interlock requirements predicts post-interlock reductions in DUI recidivism and that dedicated monitoring can increase compliance with the demands of the interlock) suggests that closely monitoring interlock drivers could result in fewer alcohol-related traffic violations after the interlock was removed. However, the logical first step was to determine the extent to which closer monitoring actually improved driver compliance with interlock requirements. To assess this relationship, we conducted a randomized controlled trial (RCT) among a statewide sample of Maryland drivers who each had multiple offenses for alcohol-impaired driving. We used data derived from dataloggers attached to the ignition interlocks to estimate effects of closer monitoring on compliance with interlock restrictions during the interlock license restriction period. Dataloggers can read electrical signals from the interlock and log these data in memory for later downloading to a computer.

The objectives of our research were as follows: 1. To determine the extent to which closer monitoring resulted in greater compliance (or less non-compliance) with requirements of the interlock systems used in the study; 2. To determine whether the extent of compliance with the interlock restriction changed or stabilized over time; 3. To assess potential effects of prior alcohol-related (AR) traffic violations on the compliance behavior of study participants.

2. Methods

2.1 Research design

Drivers with two or more prior alcohol-related traffic violations were referred to the ignition interlock license restriction program by two divisions of the Maryland Motor Vehicle Administration [the Medical Advisory Board (MAB) and Administrative Adjudications] and by Administrative Law Judges from the Office of Administrative Hearings. To be eligible for the study, these offenders had to be Maryland residents (to ensure access to driver record data) who were not already enrolled in the interlock program. They also had to be at least 21 years of age and to have accepted the interlock license restriction as a condition of relicensure.

Approximately 4,100 referrals were reviewed and 2,168 drivers met the study’s eligibility criteria. Between June 2003 and October 2004, eligible drivers were randomly assigned to either the closer monitoring (treatment) group (N = 1,083) or the standard/usual monitoring (control) group (N = 1,085). Members of both groups were issued an interlock restricted driver’s license that prohibited their driving any motor vehicle that was not equipped with an ignition interlock and datalogger. Those who did not own or have access to a vehicle in which an interlock could be installed were permitted to request a waiver, and 51 received a waiver for the duration of the trial. Another 61 drivers obtained a waiver but later installed the interlock, and 6 were initial installers but later waived installation. To ensure compliance with the license restriction, waivers were monitored according to the standard or closer-monitoring protocol relevant to their random assignment. Because this study focuses on compliance with requirements of the interlock device, the long-term waivers were excluded from these analyses.

All interlocks in this study came equipped with a datalogger to identify and record non-compliant events (such as initial and rolling-retest BACs at or above .025%, refusing to take rolling retests, or bypassing the interlock). They also recorded trip start time and duration plus driver and vehicle identification, and they could initiate engine lockouts in response to rapidly repeated breath-test failures as defined by the vendors.

Westat staff (particularly Drs. Rauch and Ahlin) were responsible for monitoring offenders randomly assigned to the closer monitoring (CM) arm of the trial, while case managers in the Ignition Interlock Unit of the Motor Vehicle Administration (MVA) were responsible for monitoring offenders randomly assigned to standard monitoring (SM), because this unit had the usual task of managing offenders assigned to Maryland's interlock license restriction program. In addition to Drs. Rauch and Ahlin, Westat subsidized a research assistant who served on site as a "case manager" at the MVA to help implement the protocol for the closer monitoring group.

2.1.1 Closer monitoring (CM)—Based on interviews with MVA officials, Westat staff developed special procedures to closely monitor the compliance behavior of drivers assigned to the closer monitoring treatment group but not drivers assigned to the control group. The datalogger tracked driving behaviors and provided objective data for monitoring compliance with interlock requirements imposed by the Maryland Motor Vehicle Administration (MVA). Drivers in the closer monitoring group received an introductory brochure explaining the ignition interlock license restriction program, violations of program requirements, and the graduated sanctions such violations would trigger.

The three interlock vendors conducting business in Maryland sent raw datalogger data to Westat on a weekly basis for all drivers who had reported for their monthly servicing appointment in the previous seven days. These data were converted to SAS files and coded to facilitate standardized summary reports detailing use of the vehicle and program violations. Each week Westat staff generated and manually reviewed reports for the closer-monitored drivers to identify the month of program participation and any violations. If no violations were recorded on the datalogger report, protocol required that a congratulatory letter be mailed to the driver through the MVA, thanking him or her for driving safely during that month and urging continued safe driving. These letters were also intended to indicate that the MVA was monitoring driver behavior.

Drivers who had violations documented on their monthly datalogger reports were notified by letter of the applicable graduated sanctions they were at risk of receiving. We recognized that communication with offenders is a crucial component of deterrence-based interventions (Kennedy, 2006) and that the threat of added sanctions should function as a deterrent through negative reinforcement of violation-prone behavior (Pratt et al., 2006), thereby motivating drivers to change their actions (McBride and Peck, 1970). Letters that notify problem drivers of relevant sanctions are often used by motor vehicle agencies and are thought to be more effective in reducing recidivism than letters with a softer sell (Jones, 1997). Compared to alternatives like in-person counseling, letters are also relatively inexpensive.

For their first interlock violation, the closer-monitored drivers were sent a warning letter describing the infraction and sanctions for future violations, but giving them time to change their behavior. Drivers who had a second month involving a datalogger violation were instructed to report to their interlock vendor for an extra mid-month monitoring and downloading of the datalogger. Those who had violations during three or more months were required to report to the MVA Medical Advisory Board for a physician's evaluation. At this interview, the physician evaluated the driver's alcohol problem and could recommend additional interventions and/or treatment, including extending required time on the interlock.

If violations occurred during two consecutive months, study protocol permitted a one-month delay for notification of sanctions, because these drivers would not have received their violation letter for Month 1 until after "real time" datalogger monitoring for Month 2 began.

Thus, we could not expect to see behavioral change before Month 3. Although Westat staff prepared the violation and congratulatory letters, they were actually mailed by the MVA.

During the study's peak enrollment, more than 1,000 drivers assigned to closer monitoring were monitored each month; 89% of them violated program requirements at least once during the interlock period, and 53% incurred violations during three or more months and were referred to an MAB physician. To assist with these increased referrals**,** the MAB hired an additional physician. Our records show that 88% of the CM offenders who were notified of the need to meet with an MAB physician made an appointment to do so, and 97% appeared for that appointment. However, study staff had no control over the physician's choice of sanctions or the driver's response to sanctions imposed.

2.1.2 Standard monitoring (SM)—For drivers randomly assigned to the standard-monitoring control group, compliance with interlock requirements was monitored according to the usual and customary MVA practices that pre-existed the study. There was no documented protocol specifying standardized procedures for enrolling drivers, monitoring them during the interlock program, or suspending or terminating their involvement. Therefore, any monitoring and sanctioning that occurred varied widely among the case managers, even though the technical definition of a violation was the same for both study groups. In trials such as ours, it may be difficult or impossible to document standard or usual procedures because they are often undefined and variably enforced. We relied on observations by Westat study staff, information from reliable sources within the MVA, and a mandated audit by Maryland's General Assembly.

The guiding protocol for staff in the Ignition Interlock Unit was to have the device installed in a vehicle as required by statute and to remove the license restriction after the specified time period had elapsed. Drivers in the standard monitoring group were often given the "benefit of the doubt" regarding breath test failures and ignition bypasses, particularly for less reliable interlock equipment. Datalogger reports from the vendors received cursory review, and reports without evidence of any violations (as determined by the vendors) were discarded. Although reported violations may have resulted in warning letters to offenders, there were no established rules as to when that should happen, and most often no further action (such as license suspension) was taken. Information at our disposal indicated that drivers in the standard monitoring group were free to violate program requirements, with essentially no repercussions.

Even egregious violations by these drivers during their final 45 days in the program (e.g., disconnecting the interlock, refusing rolling retests, or logging numerous breath alcohol tests at or above the preset limit of .025) remained unsanctioned. At the end of their intervention period, participants were sent a congratulatory letter for successfully completing the interlock program, and despite these violations, their driver's licenses were fully reinstated. Some drivers assigned to closer-monitoring also committed serious violations of interlock requirements toward the end of their program, but the MAB would be alerted to consider delayed reinstatement.

Perhaps the most valid evidence of the weak standard monitoring by the MVA comes from an audit conducted by the Maryland legislature from January 1, 2004 to November 30, 2006 (Maryland General Assembly, 2007). The audit concluded that MVA policies and procedures were not sufficient to identify and address Ignition Interlock Program violations. These inadequacies were exemplified by failure to take appropriate follow-up and corrective actions, delayed processing of license suspensions and revocations, deficient supervisory review of caseworker decisions, and faulty sharing of information within the MVA regarding pertinent license actions recorded in driver records. In a review of 20 drivers enrolled in the interlock program as of May 2005, 11 had incurred between 5 and 43 “significant” violations, such as breath test failures and rolling-retest refusals. None had their conditional license suspended or revoked, and the Interlock Unit was unaware that 2 had acquired speeding violations in vehicles devoid of interlocks. Drivers who had completed their required term on the interlock were notified of their “successful completion” and were returned to full driving status.

2.2 Non-compliance/compliance statistics from datalogger records

Westat’s database for this study was derived from multiple sources (such as the MVA, court records, and interlock vendors) and integrated into a single analytic file. That file included: driver characteristics, pre-enrollment alcohol-related traffic violations, and their administrative and/or judicial disposition (Ahlin et al., 2011); post-enrollment alcohol-related and non-alcohol-related traffic violations; study logistics such as interlock enrollment and termination dates; and datalogger statistics for non-compliant and compliant events which are the focus of this study. Driver data were available for analysis from the start of enrollment in June 2003 until the final extraction of MVA data on May 21, 2006, resulting in almost a three-year study period.

Westat staff developed 13 indicators of non-compliance (or compliance) with requirements of the interlock systems used in this study. Because each vendor had a distinct check-off list of violations recorded by its datalogger, staff reviewed the myriad of possible indicators and selected those that appeared to be universal across vendors and most relevant to the task at hand. Table 1 defines each of these variables.

We calculated initial breath test failure rates per 1,000 engine starts two ways for each of three BAC thresholds (.025 g/dL, .04 g/dL, and .08 g/dL) by counting as separate events multiple failed attempts to start the engine that were 5 or more minutes apart or 60 or more minutes apart. We also calculated rates per 1,000 engine starts for interlock disconnects, retest refusals, retest failures, and startup violations. Then we derived two summary measures:

a. A weighted average of all initial breath test failure rates. Weights 1, 2, and 4 were used for failures at BAC thresholds of .025 g/dL, .04 g/dL, and .08 g/dL respectively. These weights were chosen to penalize high threshold failures more than low threshold failures; b) The summed total of all non-compliance rates, including the weighted test failure rates.

In addition, we computed “initial breath tests passed per month,” which is not a pure measure of compliance because it can also reflect the frequency of driving and therefore attempts to start the vehicle. Lastly, we calculated separate sets of compliance statistics for drivers with at least 6, 12, or 24 consecutive months of datalogger data.

2.3 Statistical analyses

To obtain a general sense of the pattern of non-compliance with interlock restrictions among treatment and control group drivers, for each assignment group we computed average non-compliance statistics based on at least 6, 12, or 24 consecutive months of datalogger data. The interpretation of these averages is straightforward. For example, in the treatment group, the rate of initial fails, using the .025 BAC threshold for failures 5 or more minutes apart, was 4.9 per 1,000 engine starts among drivers with at least 6 consecutive months of datalogger data.

We then used linear regression analysis to estimate the effects of closer monitoring on these non-compliance statistics. Drivers could have up to three values for each indicator of non-compliance (also referred to as *measures*), one per at least 6, 12, or 24 months of continuous datalogger data. This suggested using *repeated measures* models because they allow for within-driver correlation among repeated measures of the same non-compliance/compliance statistic.

We included in each model two dichotomous dummy variables to identify treatment-group drivers (T = 1 for treatment group drivers and T = 0 for control group drivers) and an analogously defined dichotomous dummy variable to identify control group drivers (C = 1 for control group drivers and C = 0 for treatment group drivers). Using two dummy variables in this way made it possible to interpret the coefficients as the effect of driver group on the number of violations in each group and to calculate the differential effect of group membership as a difference between the coefficients. Besides the dummy variables, we included in the models the number of prior alcohol-related traffic violations at study enrollment. The values for the two dummy variables and for prior violations remained the same across the repeated measures of a driver.

To allow non-compliance measures to vary in terms of the number of months of continuous datalogger observations, we also included in the models the continuous variable Month (m) and the square of Month ($Month^2$ or m^2). Month squared served as a quadratic term (the effect of which is represented by regression coefficients) that assessed potential non-linear changes over time in the effects of the months of continuous time on the interlock.

The general form of the model equations we used can be expressed in terms of the 5 fixed effects [T, C, m, m^2, and prior alcohol-related traffic violations] plus an error term as follows:

$$\text{Measure}\,(d, m) = b_1 T + b_2 C + b_3 m + b_4 m^2 + b_5 \text{AR Priors} + \text{error}$$

where Measure stands for a particular non-compliance statistic, d is for driver, m is for the number of months of continuous datalogger data, m^2 refers to the quadratic term, and the letters $b_1 - b_5$ denote regression coefficients to be estimated from the data. The error term had two components: the random term associated with drivers (which we call the *random driver effect)* and the residual error associated with within-driver variation across the repeated measurements.

The difference between the effect on interlock non-compliance of standard monitoring relative to closer monitoring ($b_{diff\,=}\, b_{2\,-}\, b_1$) is estimated by the signed magnitude of coefficient b_2 minus coefficient $b_{1.}$ Similarly, the positive or negative sign of b_3 (the Month effect) shows whether non-compliance increased or decreased as the number of continuous months on the interlock increased. Moreover, the positive or negative sign of b_4 (the quadratic month effect) shows that the rate of change in the non-compliance indicator increased or decreased over months on the interlock.

Since the regression model included fixed effect variables as well as random driver effects, we used the SAS procedure Proc Mixed (SAS, 1999) to estimate model parameters and to calculate differences between closer monitored and control drivers. Our assessments of statistical significance were based on two-tailed *t*-tests.

[2]The monthly pass-rate is the number of times a driver was able to start his or her interlock-equipped vehicle during an average month. The pass-rate can increase because the driver drove more frequently during the month and/or because the interlock failed the driver less frequently.

3.0 Relevant theory

Our concept of closer monitoring of participants in interlock programs was based on theory and our own experiences in conducting randomized controlled trials among offenders assigned to interlocks. We are unaware of any previous RCT of closer monitoring per se, but two studies of interventions somewhat similar to closer monitoring have had successful outcomes.

Marques and colleagues (1998, 1999, 2000) found that driver counseling (involving motivational enhancement, education, and support services) among offenders who “self selected” themselves into an interlock program in Calgary, Canada had fewer datalogger warnings and BAC failures than interlock participants in Edmonton, Canada who did not receive counseling. A more structured motivational enhancement program involving individual and group support sessions (Timken and Marques, 2001a, b) was tested among 292 first offenders assigned (without randomization) to interlocks in Texas. Pre-post analyses showed significantly favorable changes in drinking and related problems, and retrospective comparisons of non-equivalent but matched interlock-assigned offenders showed that those exposed to the support program were significantly less likely to have elevated breath tests (Marques et al., 2004; Marques et al., 2007).

Comparisons of two intent-to-treat RCTs conducted in Maryland that tested an interlock program versus standard sanctions (Beck et al., 1999; Rauch et al., 2011) suggested that the smaller reductions in alcohol-related recidivism associated with the second interlock program resulted from poorer MVA monitoring and enforcement. This interpretation contributed to the rationale for launching our own closer-monitoring RCT, which was consonant with established theories of deterrence and behavioral change.

Thus, routine activity theory (Cohen and Felson, 1979; Felson, 2002) stresses the value of capable guardians (Bouffard et al., 2007; Gruenwald et al., 1996); incapacitation in crime-control theory (Nagin, 2000) recognizes the importance of intensive supervision; deterrence theory underscores the need for swift, certain, and appropriately severe sanctions (Beccaria, 1963; Ross, 1982); theories of operant conditioning (Skinner, 1950) and social learning (Akers, 1985; Bandura, 1977, 1986) explain how the consistency and severity of sanctions affect the duration of a behavior and behavioral change and how learned behaviors get unlearned; and theories of motivational enhancement (Miller et al., 1992) build the foundation for closer monitoring.

In operant conditioning, for example, both the interlock and its human monitor have the capacity to positively or negatively reinforce and/or punish the driver’s behavior, thereby facilitating compliance with interlock regulations (Azrin and Holz, 1966). Continuous reinforcement generally increases the rate of learning, especially during its initial stages; and consistent adequately intense punishment can effectively stop undesirable behavior (Lerman and Vorndran, 2002). Not only must drivers learn that the interlock rewards or punishes based on the amount of breath alcohol, but they must also learn to control their drinking before the desired car trip. According to Bandura’s social learning theories, people learn by observing others’ behavior in the context of continuous reciprocal interactions among cognitive, personality, and environmental influences. Through rewards and punishments, drivers learn the rules of interlock systems and also how to break them without harmful consequences. The style and intensity of oversight by designated monitors can affect the learning process, as can significant others.

4.0 Results

4.1 Demographic relationships

Of the 2,168 drivers in the study, 1,083 (essentially 50%) were closely monitored (Table 2). For all drivers combined, the average age at enrollment was 39.1; 15% were female; 11% were African American; and the average number of prior alcohol-related traffic violations was 2.62. Interlocks remained on the drivers' vehicles for an average of 1.26 years. Among all drivers, 505 had Draeger interlocks and dataloggers installed 283 had the old model of the Guardian interlock system, and 820 had the National interlock system. In addition, 560 drivers had the new redesigned Guardian device and datalogger, but only for less than 6 months. We, therefore, excluded those 560 drivers from the linear model that assessed factors affecting parameter estimates of intervention duration (SAS Procedure GLM, 1999).

That model showed that the number of alcohol-related priors at enrollment had significant positive effects on the offenders' time on the interlock, as would be expected (Estimate = 0.203, $p = 0.000$), and that drivers with the old Guardian interlock had a significantly longer average interlock period than drivers who had the National interlock (Estimate = 0.117, $p = 0.014$). However, study-group assignment, age at enrollment, and being female or African American did not have significant effects on the length of the intervention (table not shown).

4.2 Effects of closer monitoring on non-compliance

Since compliance-related statistics can be investigated only for periods during which interlocks were installed, we limited our analyses to drivers who had at least 6 months of continuous datalogger data. Based on preliminary analyses, we chose 6 months as the cutoff time to ensure statistical stability for the focal statistics. Table 3 displays those compliance statistics (per 1,000 engine starts) by study-group assignment, controlling for the number of continued months of available datalogger data.

By comparing the two study groups with at least 6 months of continuous data, we found that average non-compliance was systematically lower for the closer monitored than control drivers. The weighted overall averages of initial breath test failures per 1,000 engine starts were 2.0 for the closer monitored and 2.8 for control drivers and the combined non-compliance event rates were 23.4 and 32.0, respectively. Parallel differences also occurred for all initial breath test failures per 1,000 engine starts at all three BAC levels at least 5 minutes and at least 60 minutes apart and for disconnects, retest refusals, retest failures, and start-up violations. All these non-compliance rates were lower for closer monitored than control drivers when based on data series of at least 6, 12, or 24 months.[4]

An examination of the average maximum and minimum non-compliance values among drivers in the three separate datalogger series showed that the control group had a larger maximum value than the closer-monitoring group in 26 of the 36 comparisons (3 datalogger series times 12 indicators of non-compliance). Regardless of study group, all the minimum non-compliance values were zero, indicating that every driver complied with interlock requirements on at least one occasion (data not shown).

4.3 Effects of interlock duration on noncompliance

Perhaps most important, the downward trend in the non-compliance statistics over time on the interlock provided evidence for the presence of learning or habituation. Based on at least 6, 12, and 24 months of interlock data, the weighted overall average of initial breath test failures per 1,000 engine starts was respectively 2.0, 1.5, and 1.1 for the closer monitored

[4] In two cases, the two groups had the same rates when rounded to the first decimal.

and 2.8, 2.5, and 1.6 for the control group. Thus, the failure rates for both study groups declined as a function of the length of the interlock series. For non-compliance event-count totals, the averages for at least 6, 12, and 24 months of data were 23.4, 18.4, and 11.3 for the closer-monitored and 32.0, 29.1, and 16.9 for their controls.

Similar downward trends occurred in threshold-specific non-compliance among both study groups as the continuous data series increased, regardless of the driver's BAC level and time between failures. Furthermore, disconnects, retest refusals, and retest failures declined over time for each study group.

4.4 Model parameters and study-group differences

For each non-compliance statistic, Table 4 presents model parameter estimates for the covariates that represented study-group membership, plus their statistical significance, as well as differences between those estimates for the two groups, including statistical significance and standard errors for those differences. These findings revealed that closer monitoring had the desired effect because it significantly reduced weighted initial test failure rates and total non-compliance event counts, as well as 5 of the 6 single measures of initial breath-test failure. Closer monitoring also reduced disconnects, retest refusals, retest failures, and start-up violations, but none of these study-group differences was significant at the .05% level. In addition, the treatment group had slightly more initial breath-test passes per month than their controls, but this difference did not reach statistical significance.

Learning or habituation effects were clearly evidenced in Table 4 by the statistically significant negative coefficients for the linear term in the length of data series (Month). The linear term was −0.09 ($p < .001$) for weighted initial test failures, and −1.18 ($p < .001$) for the sum of non-compliance event rates. Analogous learning patterns were evident for initial test failures at every BAC and timing threshold, and for retest refusals. Although retest failures also had a negative coefficient (−0.08), it was not significant, $p = .059$. However, it should be noted that the quadratic term for months of continuous datalogger data was significantly positive for most indices of non-compliance, including both summary measures, which indicates that over time, learning tapered off.

The number of alcohol-related priors at the time of enrollment had inverse non-significant effects on most of the non-compliance indicators, but each additional prior at the time of enrollment was associated with a significant increase of about 4.7 in the monthly rate of initial breath tests passed. This suggests that drivers with more alcohol-related priors had a higher monthly rate of successfully starting their vehicles. Although puzzling, this finding has no implications for the comparative effectiveness of the two types of monitoring.

4.5 Summary of key findings

A. Compared to standard monitoring, closer monitoring significantly reduced:

- The frequency of initial breath test failures, 5 or more minutes apart, at or above BAC thresholds of .025 g/dL, .04 g/dL, and .08 g/dL;
- The frequency of initial breath test failures, 60 or more minutes apart, at or above thresholds of .025 and .04;
- The weighted average of all initial breath test failures, where higher weights were given to failures at higher BAC levels; and
- The weighted total non-compliance rate, which involved all types of non-compliance (initial breath test failures, interlock disconnects, retest

NIH-PA Author Manuscript

NIH-PA Author Manuscript

refusals, retest failures, and other startup violations like bypassing the interlock).

All these separate indicators of non-compliance showed lower rates (per 1,000 engine starts) for the closer-monitoring group, but only the study-group differences for initial breath-test failures were statistically significant.

B. for each study group, rates for all but one indicator of non-compliance decreased as time on the interlock increased. For all drivers combined, the linear model that controlled for other fixed effects showed that the downward trend in non-compliance over continuous months of datalogger data was statistically significant for 9 of the 12 indicators of non-compliance. These results clearly suggest that drivers learned to improve their compliance over time.

C. The positive and significant quadratic term for most indicators of non-compliance suggests that the rate of decreasing non-compliance with requirements of the interlock tapered off over time.

D. The pre-enrollment number of alcohol-related traffic violations had no significant effect on compliance behaviors we examined except that the number of priors was positively and significantly related to the average number of initial breath tests passed per month.

5.0 Discussion

5.1 Study limitations

In theory, the closer-monitoring model had built-in strategies to enhance compliance, based on stepped-up sanctions for repeated non-compliance and monthly congratulatory letters for compliance. However, the power to implement and enforce sanctions, to extend the duration of the interlock, and/or to prescribe treatment for alcohol problems rested with the MVA, and Westat does not have electronically available data concerning the extent to which specific sanctions and remedies were activated or imposed. Similarly, Westat has limited (although reliable) first-hand information about MVA's monitoring of control-group drivers, but the audit by the Maryland legislature (from 2004–2006) concluded that the MVA essentially ignored the non-compliance of interlock drivers (Madigan, 2007; Maryland General Assembly, 2007).

To be most effective, sanctions should swiftly follow violations of interlock restrictions. However, delays in timely sanctions occurred for several reasons: Datalogger data were downloaded weekly, but for the prior month; it took time to process vendor data and prepare appropriate letters; we deliberately allowed time for warnings to change behavior; technical problems arose in linking vendor data to existing MVA records, and there were other uncontrollable data-handling problems.[5] Unlike the two previous RCTs conducted in Maryland, this trial had no preset period of intervention or followup. The length of intervention was determined by the agency that prescribed conditional relicensure or its later extension or suspension. Such variability reflected reality, but it complicated some statistical analyses.

5.2 Conclusions

This study convincingly demonstrates that closer monitoring substantially increased compliance with interlock restrictions that blocked drivers from driving their vehicles with

[5]For a discussion of similar problems, see Simpson and Robertson, 2001.

even trace amounts of breath alcohol. If increased compliance over time represents learned separation of drinking from driving, ignition interlocks might be a sufficient or causally-mediated condition (Holland, 1986) for reducing alcohol-related traffic violations, but not necessarily a necessary condition, since there can be alternative ways to separate drinkers from driving.

There is mounting evidence that the public, national media, and advocacy groups for highway safety support efforts to increase use of ignition interlocks, not only because they may help alcohol-impaired drivers unlearn their propensity to drive intoxicated but because of the interlock's potential for incapacitation [Cook and Gearing, 2009; MADD, 2010; National Highway Traffic Safety Administration (NHTSA), 2007; Washington Post, 2010]. In a 2009 national survey by the Insurance Institute for Highway Safety (IIHS), 84% of respondents supported interlock use for convicted drunk drivers, and 64% said it would be a good idea to have interlocks in all cars if the technology proves reliable. By 2009, all but three states had laws or administrative regulations permitting or authorizing interlock programs (IIHS, 2009).

As ignition interlocks become more universal for first and multiple DUI/DWI offenders, key monitoring and corrective issues remain. Besides organizational and staff commitment, effective monitoring will depend on the availability of human and financial resources. The Dutch-sponsored study (Vanlaar et al., 2010) identified a minority of offenders who were clearly resistant to internalizing (learning) requirements of interlock programs. Their excessive failures at the outset stayed constant over time, and in another subgroup of offenders compliance deteriorated over time. As part of a reinforcement plan to address interlock non-compliance among hard-core drinkers, the Dutch program now includes a treatment component, and Sweden's interlock program includes regular medical checkups to alter habits of alcohol use (Bjerre and Thorsson, 2008).

Adding treatment (with accountability) to interlock programs is consistent with guidelines for sentencing DWI offenders published by NHTSA and the National Institute on Alcohol Abuse and Alcoholism (2005). Some researchers also contend that "evidence of a beneficial effect of the integration of rehabilitation and interlock programs" could strengthen relationships with treatment providers (Beirness et al., 2003, pg 181). However, treatment for alcohol problems is not a panacea (Willenbring, 2010); so alternative restraints may be necessary, especially after the interlock devices have been removed in the wake of re-licensing or indefinite license suspension.

Acknowledgments

This research was funded by the National Institute on Alcohol Abuse and Alcoholism (grant R01 AA11897). The authors wish to acknowledge the support and expertise of the late Dr. Robert Raleigh, who served as a member and Chief of the Medical Advisory Board of the Maryland Motor Vehicle Administration (1993–2005); Anne Ferro, former Administrator of the MVA; Thomas Manuel, former Director of the MVA Driver Wellness and Safety Division; and Sue Egbert Vess, case manager at the MVA, who helped implement the protocol for the closer-monitoring study group. The authors also wish to thank Kevin Frissell and Joseph Sonnefeld of Westat for their consultation. The use of data from human participants in this study was approved by the Institutional Review Board of Westat.

References

Ahlin EM, Zador PL, Rauch WJ, Howard JM, Duncan GD. First-time DWI offenders are at risk of recidivating regardless of sanctions imposed. J Crim Justice. 2011; 39 (2):137–142. [PubMed: 21603059]

Akers, RL. Deviant Behavior: A Social Learning Approach. 3. Wadsworth; Belmont, CA: 1985.

Azrin, NH.; Holz, WC. Punishment. In: Honig, WK., editor. Operant Behavior: Areas of Research and Application. Appleton-Century-Crofts; New York: 1966. p. 380-447.

Bandura, A. Social Learning Theory. Prentice-Hall; Oxford, England: 1977.

Bandura, A. Social Foundations of Thought and Action: A Social Cognitive Theory. Prentice-Hall; Englewood Cliffs, NJ: 1986.

Beccaria, C. On Crimes and Punishments. Prentice-Hall; Upper Saddle River, NJ: 1963.

Beck K, Rauch WJ, Baker EA, Williams AF. Effects of ignition interlock license restrictions on drivers with multiple alcohol offenses: A randomized trial in Maryland. Am J Public Health. 1999; 89 (11):1696–1700. [PubMed: 10553391]

Beirness DJ, Marques PR. Alcohol ignition interlock programs. Traffic Inj Prev. 2004; 5 (3):299–308. [PubMed: 15276931]

Beirness DJ, Simpson HM, Robertson RD. International symposium on enhancing the effectiveness of alcohol ignition interlock programs. Traffic Inj Prev. 2003; 4 (3):179–182. [PubMed: 14522640]

Bjerre B, Thorsson U. Is an alcohol ignition interlock programme a useful tool for changing the alcohol and driving habits of drink-drivers? Accid Anal Prev. 2008; 40 (1):267–273. [PubMed: 18215558]

Bouffard LA, Bergeron LE, Bouffard JA. Investigating the impact of extended bar closing times on police stops for DUI. J Crim Justice. 2007; 35 (5):537–545.

Cohen LE, Felson M. Social change and crime rate trends: A routine activities approach. Am Sociol Rev. 1979; 44 (4):588–608.

Cook, PJ.; Gearing, ME. Op-Ed: The breathalyzer behind the wheel. New York Times; 2009 August 31.

Felson, M. Crime and Everyday Life. Sage Publications; Thousand Oaks, CA: 2002.

Gruenwald PJ, Mitchell PR, Treno AJ. Drinking and driving: Drinking patterns and drinking problems. Addiction. 1996; 91 (11):1637–1649. [PubMed: 8972922]

Holland PW. Statistics and causal inference. J Am Stat Assoc. 1986 December.81 :945–960.

Institute for Highway Safety Insurance. Public is ready to lock out driving over the legal limit. Status Report. 2009; 44 (8):1–3.

Jones B. Age, gender and the effectiveness of high-threat letters: An analysis of Oregon's driver improvement advisory letters. Accid Anal Prev. 1997; 29 (2):225–234. [PubMed: 9088362]

Kennedy, DM. Old wine in new bottles: Policing and the lessons of pulling levers. In: Weisburd, D.; Braga, AA., editors. Policing Innovation: Contrasting Perspectives. Cambridge University Press; Cambridge, UK: 2006. p. 155-170.

Lerman DC, Vorndran CM. On the status of knowledge for using punishment: Implications for treating behavior disorders. J Appl Behav Anal. 2002; 35 (4):431–464. [PubMed: 12555918]

Madigan, N. Audit finds serious MVA flaws: Monitoring of drunken drivers, license security faulted by state. Baltimore: Sun; 2007 October 30.

Marques P, Tippetts S, Allen J, Javors M, Alling C, Yegles M, Pragst F, Wurst F. Estimating driver risk using alcohol biomarkers, interlock blood alcohol concentration tests and psychometric assessments: Initial descriptives. Addiction. 2010; 105 (2):226–239. [PubMed: 19922520]

Marques PR, Tippetts AS, Voas RB. Comparative and joint prediction of DUI recidivism from alcohol ignition interlock and driver records. J Stud Alcohol. 2003; 64 (1):83–92. [PubMed: 12608487]

Marques PR, Tippetts AS, Voas RB, Beirness DJ. Predicting repeat DUI offenses with the alcohol interlock recorder. Accid Anal Prev. 2001; 33 (5):609–619. [PubMed: 11491241]

Marques, PR.; Tippetts, AS.; Voas, RB.; Danseco, ER.; Beirness, DR. Support services provided during interlock usage and post-interlock repeat DUI: Outcomes and processes. In: Laurell, H.; Schlyter, F., editors. Proceedings of the 15th International Conference on Alcohol, Drugs and Traffic Safety. Stockholm, Sweden: 2000. p. 1127-1132.

Marques, PR.; Voas, RB. DOT HS 811 262. National Highway Traffic Safety Administration; Washington, DC: 2010. Key Features of Ignition Interlock Programs.

Marques PR, Voas RB, Hodgins D. Vehicle interlock programs: Protecting the community against the drunk driver. J Prev Interv Community. 1998; 17 (1):31–44.

Marques, PR.; Voas, RB.; Tippetts, AS. Preliminary outcomes from a Texas manual-based group motivational intervention supplement for court-stipulated interlock DUI offenders. Proceedings of the 17th International Conference on Alcohol, Drugs and Traffic Safety; Glasgow, UK. 2004.

Marques P, Voas R, Tippetts A, Beirness D. Behavioral monitoring of DUI offenders with the alcohol ignition interlock recorder. Addiction. 1999; 94 (12):1861–1870. [PubMed: 10717964]

Marques, P.; Voas, R.; Tippetts, S.; Blackman, K.; Timken, D.; Field, C. Motivational intervention keyed to interlock use reduces the rate of positive BAC tests. In: Logan, BK.; Isenschmid, DS.; Walsh, JM.; Beirness, D.; Morland, J., editors. Proceedings of the 18th International Conference on Alcohol, Drugs and Traffic Safety. Seattle, WA: 2007.

Maryland General Assembly, Office of Legislative Audits, Department of Legislative Services. Audit Report. Maryland Department of Transportation, Motor Vehicle Administration; Hanover, MD: October. 2007

McBride RS, Peck RC. Modifying negligent driving behavior through warning letters. Accid Anal Prev. 1970; 2 (3):147–174.

Miller, WR.; Zweben, A.; Diclemente, CC.; Rychtarik, RG. NIAAA Project MATCH Monograph Series. Vol. 2. National Institute on Alcohol Abuse and Alcoholism; Rockville, MD: 1992. Motivational Enhancement Therapy Manual: A Clinical Research Guide for Therapists Treating Individuals with Alcohol Abuse and Dependence.

Mothers Against Drunk Driving (MADD). [Accessed March 3, 2010] Drunk Driving: Support ignition interlocks for all convicted DUI offenders. Downloaded from: https://secure2.convio.net/madd/site/Advocacy?JServSessionIdr004=08v7ubeh61.app7a&pagename=homepage&id=477

Nagin, D. Deterrence and incapacitation. In: Tonry, M., editor. The Handbook of Crime and Punishment. Oxford University Press; New York: 2000. p. 345-368.

National Highway Traffic Safety Administration. NHTSA urges increased use of ignition interlocks for repeat drunk driving offenders. August 22. 2007 Downloaded from http://www.nhtsa.gov/About+NHTSA/Press+Releases/2007/NHTSA+Urges+Increased+Use+of+Ignition+Interlocks+for+Repeat+Drunk+Driving+Offenders. (Accessed January 28, 2011)

National Highway Traffic Safety Administration. [Accessed March 31, 2011] Model Specifications for Breath Alcohol Ignition Interlock Devices (BAIIDs). Federal Register 75 FR 61820. 2010 October 6. URL http://federalregister.gov/a/2010-25131

National Highway Traffic Safety Administration and National Institute on Alcohol Abuse and Alcoholism. DOT HS 810 555. 2. National Highway Traffic Safety Administration and National Institute on Alcohol Abuse and Alcoholism; Washington, DC: 2005 January. A Guide to Sentencing DWI Offenders. 2006

Pratt, TC.; Cullen, FT.; Blevins, KR.; Daigle, LE.; Madensen, TD. The Empirical status of deterrence theory: A meta-analysis. In: Cullen, FT.; Wright, JP.; Blevins, KR., editors. Taking Stock: The Status of Criminological Theory, Volume 15, Advances in Criminological Theory. Transaction; New Brunswick, NJ: 2006. p. 367-395.

Rauch WJ, Ahlin EM, Zador PL, Howard JM, Duncan GD. Effects of administrative ignition interlock license restrictions on drivers with multiple alcohol offenses. J Exp Criminol. 2011 in press.

Ross, HL. Deterring the Drinking Driver: Legal Policies and Social Control. Lexington Books; Lexington, MA: 1982.

SAS Institute. SAS/STAT © User's Guide, Version 8. SAS Institute, Inc; Cary, NC: 1999.

Simpson, HM.; Robertson, RD. DWI system improvements for dealing with hard core drinking drivers: Enforcement. Traffic Injury Research Foundation; Ottawa, Canada: 2001.

Skinner BF. Are theories of learning necessary? Psychol Rev. 1950; 57 (4):193–216. [PubMed: 15440996]

Timken, D.; Marques, PR. Support for Interlock Planning (SIP): Participants Workbook. Pacific Institute for Research and Evaluation; Calverton, MD: 2001a.

Timken, D.; Marques, PR. Support for Interlock Planning (SIP): Providers Manual. Pacific Institute for Research and Evaluation; Calverton, MD: 2001b.

Vanlaar, W.; Robertson, R.; Schaap, D.; Vissers, J. Understanding behavioural patterns of interlocked offenders to inform the efficient and effective implementation of interlock programs: How offenders on an interlock learn to comply. Traffic Injury Research Foundation; Ottawa, Canada: September. 2010

Washington Post. Editorial: Grounding drunk drivers. Washington Post; 2010 February 8.

Willenbring ML. The past and future of research on treatment of alcohol dependence. Alcohol Res Health. 2010; 33 (1–2):55–63.

Willis C, Lybrand S, Bellamy N. Alcohol ignition interlock programmes for reducing drink driving recidivism. Cochrane Database of Systematic Reviews. 2004; (4):Art. No.: CD004168.10.1002/14651858.CD004168.pub2

Research Highlights

- This randomized controlled trial tested closer monitoring of interlock drivers.
- The control group experienced standard (usual) monitoring of interlock behavior.
- Compliance with requirements of interlock systems served as outcome measures.
- Closer monitoring of drivers with ignition interlocks reduced breath-test failures.
- Over time drivers increased compliance with mandates of ignition interlocks.

Table 1

Measures of Non-Compliance with Interlock Requirements

Measures	Definitions of Measures of Non-Compliance
Initial Fails ≥.025 5 minutes	Initial breath test failure BAC≥.025 per 1,000 engine starts 5 or more minutes apart
Initial Fails ≥.025 60 minutes	Initial breath test failure BAC≥.025 per 1,000 engine starts 60 or more minutes apart
Initial Fails ≥.04 5 minutes	Initial breath test failure BAC≥.04 per 1,000 engine starts 5 or more minutes apart
Initial Fails ≥.04 60 minutes	Initial breath test failure BAC≥.04 per 1,000 engine starts 60 or more minutes apart
Initial Fails ≥.08 5 minutes	Initial breath test failure BAC≥.08 per 1,000 engine starts 5 or more minutes apart
Initial Fails ≥.08 60 minutes	Initial breath test failure BAC≥.08 per 1,000 engine starts 60 or more minutes apart
Total Fails Weighted	Weighted average of failure rates = (.025 + 2 × .04 + 4 × .08)/7
Total Non-compliance	Weighted sum of non-compliance rates = (7 × total failures + disconnects + retest refusals + retest failures + startup violations).
Disconnects	Disconnecting power to the hand set or ignition interlock per 1,000 engine starts
Retest Refusal	Rolling retest was requested but no breath blow was provided per 1,000 engine starts
Retest Failure	Rolling retest breath blow provided was ≥ .025 per 1,000 engine starts
Startup Violation[a]	Starting the vehicle by by-passing the ignition per 1,000 engine starts*
Initial Passes Per Month	Average number of initial breath tests passed per month

[a]Vendor manuals provided to drivers assigned to ignition interlocks offer several different interpretations of “start-up violations.” In some cases, the “violation” may be inadvertent rather than deliberate, when the driver follows incorrect procedures or there is a hardware problem. However, the term “start-up violation” usually means that the driver has circumvented the proper operation of the interlock system either by providing a jumper wire across the interlock relay or by providing battery power directly to the vehicle’s starter.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 2

Driver Characteristics and Interlock Duration by Study Group Assignment

Study Group	N	Age at Start	% Females	% African Americans	Interlock Period	Alcohol-Related Prior Violations
All	2,168	39.1	15	11	1.26 yrs	2.62
Control	1,085	38.9	16	11	1.25 yrs	2.60
Treatment[a]	1,083	39.3	15	11	1.28 yrs	2.63

[a]Closer-Monitored Study Group

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 3

Datalogger Summary Statistics by Study Group Assignment and Number of Continuous Months of Datalogger Data (Month)

Month	**6**	**6**	**12**	**12**	**24**	**24**
Study Group	C[a]	T[a]	C	T	C	T
N[b]	772	785	543	579	129	119
Initial Fails ≥.025 5 minutes[c]	6.9	4.9	6.2	3.9	4.2	2.9
Initial Fails ≥.025 60 minutes	4.7	2.8	4.0	2.1	1.8	1.7
Initial Fails ≥.04 5 minutes	4.0	2.7	3.5	2.1	2.3	1.5
Initial Fails ≥.04 60 minutes	2.7	1.6	2.2	1.1	0.9	0.8
Initial Fails ≥.08 5 minutes	1.3	0.9	1.1	0.7	0.7	0.4
Initial Fails ≥.08 60 minutes	0.8	0.5	0.7	0.3	0.2	0.2
Total Fails Weighted	2.8	2.0	2.5	1.5	1.6	1.1
Total Non-compliance	32.0	23.4	29.1	18.4	16.9	11.3
Disconnects	4.3	3.4	4.0	2.8	2.3	1.4
Retest Refusals	4.1	3.1	4.0	2.4	0.9	0.9
Retest Failures	2.7	2.3	2.3	2.0	1.4	1.2
Startup Violations	0.9	0.5	1.3	0.4	0.8	0.3
Initial Passes Per Month	138	144	136	141	138	154

[a] C represents the Control group, and T (for Treatment) represents the Closer-monitored group.

[b] The N's in columns labeled 6, 12, or 24 represent the number of drivers with respectively at least 6, 12, or 24 months of consecutive datalogger data.

[c] As noted, rates are per 1,000 engine starts.

Table 4

Parameter Estimates for Fixed Effects[a] (C group, T group, Month, Month^2, and Alcohol-Related Priors) and Study-Group Contrasts (C-T)[b] in Linear Models for Datalogger Non-Compliance Statistics[c]

Measures	C	T	C – T *(SE)*	Month	Month^2	Alcohol- Related Priors
Initial Fails ≥.025 5 min	8.44***	6.37***	2.07*** (0.47)	−0.23***	0.005*	−0.13
Initial Fails ≥.025 60 min	6.20***	4.33***	1.87*** (0.50)	−0.26***	0.006**	−0.06
Initial Fails ≥.04 5 min	4.97***	3.68***	1.29*** (0.30)	−0.13***	0.003*	−0.11
Initial Fails ≥.04 60 min	3.65***	2.60***	1.05** (0.35)	−0.17***	0.004**	−0.04
Initial Fails ≥.08 5 min	1.64***	1.26***	0.39** (0.13)	−0.04*	0.001	−0.06
Initial Fails ≥.08 60 min	1.12***	0.80***	0.33 (0.19)	−0.06**	0.002*	0.01
Total Fails Weighted	3.56***	2.68***	0.89*** (0.22)	−0.09***	0.002*	−0.08
Total Non-compliance	40.48***	31.12***	9.36*** (2.50)	−1.18***	0.027**	−0.77
Disconnects	6.46***	5.44***	1.02 (1.07)	−0.13	0.003	−0.55
Retest Refusals	5.19***	4.02***	1.17 (0.89)	−0.35***	0.010**	0.30
Retest Failures	3.19***	2.80***	0.39 (0.29)	−0.08	0.001	−0.02
Startup Violations	0.66	0.07	0.59 (0.34)	0.03	−0.001	0.08
Initial Passes Per Month	130.69***	135.92***	−5.23 (3.46)	−0.72*	0.004	4.68***

* $p<.05$

** $p<.01$

*** $p< .001$

[a] Parameter estimates for Month and Month^2 (month squared) specified a quadratic function to describe non-compliant behavior over time. The Month column contains coefficients for the linear term in the length of continuous data series. The Month^2 column contains coefficients for the quadratic term for months of continuous datalogger data.

[b] These contrasts estimated study-group effects on datalogger statistics.

[c] Model parameters for the effects included in the regressions were estimated using mixed models that also included random driver effects.