J Exp Criminol (2011) 7:127–148
DOI 10.1007/s11292-010-9118-0

# Effects of administrative ignition interlock license restrictions on drivers with multiple alcohol offenses

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Published online: 8 October 2010


**Abstract** This study investigated, under real-world conditions, whether a statewide 2-year administrative ignition interlock license restriction program in Maryland was effective in reducing subsequent alcohol-related traffic violations among multiple offenders and whether any reductions in recidivism could be maintained after the program ended and interlock license restrictions were removed. A total of 1,927 drivers eligible for relicensure were randomly assigned to either the 2-year interlock license restriction program or the normal and customary sanctions afforded multiple offenders in Maryland. Recidivism was defined as incurring a subsequent alcohol-impaired driving violation during the 2-year intervention or 2-year postintervention periods. Compared to the control group, participation in the interlock license restriction program reduced drivers' hazard (or risk) of a subsequent alcohol-impaired driving offense by a statistically significant 36% during the 2-year intervention, 26% during the 2-year postintervention period, and 32% during the entire 4-year study period. This investigation of interlock program effectiveness is the first to report significantly lower recidivism among the interlock group than its control group after the ignition interlock license restriction program ended. Possible reasons for this novel finding and areas for future research are discussed.

**Keywords** Administrative program · Driving while intoxicated/Driving under the influence · Ignition interlock · Randomized controlled trial

## Introduction

Efforts to reduce the consequences of drinking and driving have met with considerable success during the past three decades. In 1982, approximately 60% of motor vehicle fatalities were alcohol-related. By 2004 that proportion had declined

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to 40% (Yi et al. 2006), and by 2008 less than one-third (32%) of nationwide driving fatalities were associated with alcohol (NHTSA 2009). Despite this success, drinking and driving continues to be a major public health problem. In 2008, 11,773 deaths occurred in crashes involving a driver or motorcycle rider who had a blood alcohol concentration (BAC) of .08 g/dl or higher (NHTSA 2009). In addition, 229,636 people suffered non-fatal injuries from alcohol-involved motor vehicle traffic crashes in 2008.[1] For the year 2000, it was estimated that the annual cost of alcohol-related crashes was more than $51 billion (Blincoe et al. 2002).

During the past 15 years, agencies responsible for highway safety in the United States and other countries have shown increasing interest in breath alcohol ignition interlocks as a promising intervention to reduce alcohol-impaired driving and its hazardous consequences. The ignition interlock device, one of several components of an effective interlock program, prevents an alcohol-impaired driver from starting and operating a vehicle in which it is installed by requiring drivers to pass an initial breath test before starting the vehicle and additional breath tests (i.e., rolling retests) while the car is being driven. Breath test limits are predetermined by the agency responsible for monitoring compliance and are programmed into the device. Typically, interlocks are set to fail when the driver's BAC is at or above .025% (Marques and Voas 2010).

Vehicles are also equipped with a datalogger device that records vehicle usage and non-compliance with the interlock device. Dataloggers record the time and date of non-compliant events, results of both initial breath tests and rolling retests, and attempts to bypass the ignition interlock by disconnecting the device and starting the vehicle without taking a breath test (Marques and Voas 2010). By separating the act of drinking from the act of driving, ignition interlock programs offer offenders arrested for driving under the influence (DUI) or driving while intoxicated (DWI) opportunities to obtain an interlock-restricted driver's license and legally drive a motor vehicle.

As of April 2009, 47 states and the District of Columbia had laws or administrative regulations authorizing the use of interlock programs (Insurance Institute for Highway Safety 2009). In August 2008, data from interlock providers showed that there were 146,337 installed ignition interlocks in the United States, representing an increase of 48% since 2006 (Roth 2008). By September 2009, reports indicated that 180,000 interlocks were in use nationwide (Insurance Institute for Highway Safety 2009).

Numerous studies, with varying methodological rigor, have evaluated ignition interlocks and related programs from the standpoint of their efficacy and effectiveness. In its December 2007 report to Congress, the NHTSA concluded that these devices have shown "effectiveness in reducing impaired-driving arrests while on the vehicles of convicted DWI offenders," but these benefits disappear once the interlocks are removed (Compton and Hedlund 2007: 15). Consistent with this conclusion, a review by the U.S. Task Force on Community Preventive Services (appointed by the Centers for Disease Control and Prevention) reported a median

[1] This estimate was generated by the National Center for Statistics and Analysis of the National Highway Traffic Safety Administration as of October 22, 2009.

reduction in rearrest rates of 73% while the interlocks were installed (Guide to Community Preventive Services 2007).

In terms of the scientific integrity of interlock studies, the systematic review of these studies conducted for the Cochrane Collaboration in 2004 prompted considerable concern (Willis et al. 2004). Although interlock participants had lower recidivism rates than their respective controls in all 14 controlled trials evaluated (including ten with statistically significant differences), none showed postintervention effectiveness, and only one was a randomized controlled trial (RCT). Thus, the reviewers stated that "overall effectiveness" of the device was questionable from a traffic safety perspective and that methodological problems, low participation rates, and having only one RCT prevented scientifically valid conclusions about interlock programs. Recognizing that strategies to improve participation, compliance, and durability of effect are challenging, the reviewers recommended that more RCTs be conducted to eliminate selection bias and allow program effectiveness and efficacy to be determined. Despite their concerns, they also noted that interlock programs have the potential to reduce the frequency of DUI/DWI as well as alcohol-related crashes.

Since this review, several more studies of interlock programs have been conducted (Bjerre 2005; Bjerre and Thorsson 2008; Bjerre et al. 2007a, b; DeYoung 2002; Roth et al. 2007a, b), but they have limitations similar to prior research. For example, participation in interlock programs may be limited to volunteers (Bjerre and Thorsson 2008) who may differ from other offenders in their dependency on alcohol (Bjerre 2005); participants may be dismissed during the study for lack of sobriety (Bjerre et al. 2007b); and self-selected interlock installers may be compared with non-installers (Roth et al. 2007a, b). Examples of research limitations from the Cochrane review include controlled trials that were administered through the courts, which, in the absence of randomization, can lead to judicial bias in the choice of interlock participants; and comparison groups may be composed of offenders who refused the interlock option or were still on license suspension, which has implications for less or more cautious driving by participants (Willis et al. 2004).

The only RCT published to date (Beck et al. 1999) involved multiple DUI/DWI offenders from Maryland and used an intent-to-treat analysis, whereby all participants were analyzed according to their assigned group regardless of their level of compliance with their assigned conditions of relicensure. This is a conservative approach to data analysis involving randomized trials (Lachin 2000), which permits estimates of the effectiveness of real-world applications of interlock programs. In that RCT, the 698 offenders assigned to the administrative ignition interlock license restriction program for 1 year showed a statistically significant 64% reduction in recidivism compared to the 689 assigned to the customary sanctions[2] afforded multiple offenders in Maryland. During the postintervention year, the control group actually had a lower recidivism rate than drivers in the interlock group, but that difference was not significant. Thus, for the 2 years of study combined, the

[2] Drivers in the control group were enrolled in the state's Drinking Driver Monitor Program (DDMP) and were monitored by probation officers for compliance with relicensure requirements and sobriety. Probation under DDMP included adherence to conditions of relicensure such as participation in treatment or self-help meetings and regular breath testing.

interlock group showed a significant 36% reduction in recidivism compared to the control group (Beck et al. 1999).

To address some of the weaknesses in previous interlock studies and the concerns of the systematic review conducted by the Cochrane Collaboration, we decided to conduct a second RCT in Maryland. We improved upon the first RCT by increasing the duration of the intervention and postintervention periods to 2 years for each, resulting in an overall 4-year study, and we increased the total number of participants to 1,927 to enhance statistical power. However, we preserved the random assignment, usual-care control group, administrative oversight, and intent-to-treat design under real-world conditions used in the first RCT.

Basically, the objective of the present study was to determine whether a 2-year administrative ignition interlock license restriction program among multiple alcohol-impaired driving offenders would prove to be more effective in reducing the overall magnitude and durability of recidivism than the earlier 1-year intervention. Given its intent-to-treat design, the present RCT tested effects of the combined features of the interlock license restriction program, not simply the interlock devices per se.

This study also addresses Compton and Hedlund's (2007) observation that the effects of interlock programs appear to be limited to the interlock intervention period. Several studies have demonstrated an incapacitative effect while the interlock device is installed or the interlock license restriction program is in effect. Drivers who are impaired by alcohol are incapacitated from operating a vehicle that has an installed interlock device because the ignition will not start, thereby removing the driver's ability to offend. Theoretically, the license restriction also incapacitates a driver by constraining him or her from operating a vehicle not equipped with an interlock.

Interlock programs may additionally provide a deterrent effect after the ignition interlock license restriction is no longer enforced. Specific deterrence aims to reduce recidivism among known offenders through the imposition of consequences. For drivers eligible for this study, one of the consequences for a second or subsequent alcohol-impaired driving violation is an ignition interlock license restriction. Under specific deterrence it is believed that punishment applied to an offender will positively impact future behavior and reduce recidivism because the consequences associated with repeat offending are known. We test the specific deterrence hypothesis by examining if a 2-year incapacitation period influences recidivism after the intervention period ends.

## Methods

### Participants

Participants in our RCT were Maryland drivers with two or more alcohol-related traffic violations in their lifetime who sought license reinstatement after completing their license suspension period and other prelicensure sanctions and were approved for relicensure by the state's Medical Advisory Board. During the 2-year intervention period, regardless of their study assignment, all drivers were prohibited from legally operating a motor vehicle with any amount of alcohol in their system.

## Procedures

All 1,927 offenders were randomly assigned by the Medical Advisory Board to either the ignition interlock license restriction program ($n$=944) or the control group ($n$=983) for a period of 2 years. Enrollment of participants took place during the years 2000 and 2001. Drivers assigned to the interlock program were notified by letter that they were approved for relicensure contingent upon enrollment in the state's interlock license restriction program. They then had 30 days to have the interlock installed or face suspension for failure to comply with program requirements. Because the Motor Vehicle Administration (MVA) cannot prevent drivers from becoming relicensed simply because they do not own, co-own, or have access to a vehicle in which to install an interlock, these drivers were still enrolled in the interlock program but were permitted to apply for an interlock waiver. Like those who installed the interlock, drivers obtaining a waiver also received an interlock-restricted license prohibiting them from legally operating a vehicle devoid of an ignition interlock.[3] The interlock restriction was clearly visible in bold red letters on the front of the license. Only the failed-to-comply subgroup did not receive the restricted license because they remained suspended.

Drivers randomly assigned to the control program were notified by letter that they were approved for relicensure pending enrollment in the state's Drinking Driver Monitor Program as required by the Medical Advisory Board. This program required drivers to routinely report to a probation monitor who supervised program compliance with respect to drinking and driving and overall sobriety. Probation monitors administer breathalyzer tests to participants, ensure attendance at treatment or self-help meetings, and enforce other conditions of probation.

Drivers were enrolled in their respective programs for a period of 2 years and were monitored for an additional 2 years postintervention. The outcome of interest was alcohol-related traffic recidivism (i.e., one or more subsequent violations which is the inverse of violation-free survival). Participants were tracked by the MVA, which provided all data for the study after removing driver identifiers.

## Dependent measures

In Maryland, an alcohol-related traffic violation may result in administrative penalties mandated under administrative per se regulations for failing or refusing the breath alcohol test or in criminal penalties mandated by a conviction. Breath alcohol tests usually are administered by law enforcement at roadside for suspicion of DUI/DWI. Following a conviction or *nolo contendere* plea, an offender also can be placed on probation before judgment, a so-called diversion program. Therefore, in this study, an alcohol-related violation refers to any arrest for DUI or DWI that resulted in a preconviction administrative sanction, a conviction, probation before judgment, or their combination. The inclusion of all these disposition types for

[3] If an employer required a driver (assigned to the interlock group) to drive a company vehicle during the course of employment, the driver could apply for an employer-vehicle exemption waiver, which may or may not have been approved by the MVA.

alcohol-related violations provides a more complete history of the prevalence of alcohol-impaired driving (Rauch et al. 2003).

## Time lag

It can take up to 1.75 years for alcohol-related violations to work their way through the administrative and judicial systems, reach a final adjudication, and appear on the driver's record (Rauch et al. 2003, 2005). Therefore, analyses of potential recidivism were delayed until about 6 years after the last driver had enrolled in his or her respective assigned program, thereby covering two intervention and two post-intervention years plus a potential 2-year time lag until final disposition and recording of the subsequent alcohol-related violation.

## Data analysis

We used an intent-to-treat approach for data analysis. All participants were analyzed according to their assigned group, regardless of compliance with or deviations from their specific program requirements. Thus, we followed all 1,927 participants over the course of the study. First, we plotted the proportions of drivers remaining free of alcohol-related traffic violations in the interlock and control programs as a function of time for the 2-year intervention and 2-year postintervention periods. Time was measured from the program enrollment date for the 2-year intervention and from the intervention end date for the 2-year postintervention period. The plots were constructed using the product limit Kaplan–Meier method (Kaplan and Meier 1958) as implemented in the SAS PROC LIFETEST (SAS Institute 1999). Participants were censored at the earliest of the following incidents or dates: deceased, moved out-of-state/emigrated, 2 years after enrollment (2-year intervention analysis), 2 years after the end of the intervention period (2-year post-intervention analysis), or 4 years after enrollment (4-year analysis). A total of 58 drivers died and 68 moved out-of-state during the study. The proportion of participants who died or moved out-of-state did not differ significantly between the interlock and control groups.

Next, we estimated the effects of potential risk factors on the probability of alcohol-related violation-free survival during the intervention, postintervention, and overall 4-year study periods by semi-parametric survival analyses using Cox's proportional hazards models (Cox 1972; Cox and Oakes 1984). We included potential covariates for driver age, sex, race, prior alcohol-related violations at program enrollment, and the violation disposition category (VDC) for the index offense that qualified the driver for enrollment. VDC is the chronological sequence (or process) by which an offender passes through the administrative and/or judicial systems. Each offender was classified into one of eight possible and mutually exclusive VDCs (Table 1). We also included out-of-state alcohol-related traffic violations in the analysis for participants during the study if those violations were reported to the MVA and recorded in the MVA driver record database.

In addition, we included a binary flag (0=interlock/1=control) that represented each driver's random assignment status. Thus, a positive estimate for the flag's

**Table 1** Violation disposition categories (VDC) for alcohol-related traffic violations

| VDC code | Disposition sequence | Definition |
|---|---|---|
| VDC 1 | APS failure (APS+) | Breath alcohol test ≥ .10%,* not convicted |
| VDC 2 | APS+, conviction | Breath alcohol test ≥ .10%,* convicted |
| VDC 3 | APS+, conviction, probation before judgment (PBJ) | Breath alcohol test ≥ .10%,* convicted, received PBJ |
| VDC 4 | APS refusal | Refused breath alcohol test, not convicted |
| VDC 5 | APS refusal, conviction | Refused breath alcohol test, convicted |
| VDC 6 | APS refusal, conviction, PBJ | Refused breath alcohol test, convicted, received PBJ |
| VDC 7 | Alcohol-related conviction | Breath alcohol test not administered, convicted |
| VDC 8 | Alcohol-related conviction, PBJ | Breath alcohol test not administered, convicted, received PBJ |

* ≥ .08% as of October 1, 2001

regression coefficient points to a higher hazard ratio and, consequently, lower survival probability in the control group than interlock group. The interlock effect on survival probability is estimated by the negative regression coefficient of the assignment-status flag. To fit our proportional hazards models to our alcohol-related violation data, we used the SAS PHREG procedure (SAS Institute 1999).

For the three time periods of interest, we also computed relative risks, using two different approaches: directly with no adjustment for covariates and approximately based on proportional hazard model parameters that were adjusted for demographic and other covariates.

## Results

### Descriptive statistics

As shown in Table 2, the interlock and control groups had similar proportions of women (11%, 13%), Caucasians (79%, 81%), African-Americans (17%, 14%), Asians (1%, 1%), and other or unknown races (4%, 3%).[4] The mean age at program enrollment was 40 in both groups with approximately the same age distributions, ranging from 21 to 75 and 22 to 77, respectively. In both groups, the average number of prior alcohol-related violations was 3.3, and the proportions of drivers with 2 (29%, 30%), 3 (36%, 34%), and 4+ (35%, 37%) alcohol-related priors were almost identical in the two groups, with maximums of 14 and 11, respectively. None of these interlock-control demographic differences was statistically significant at the 95% confidence level.

The interlock and control groups also did not significantly differ in the VDC of their index offense (Table 3). They showed similar distributions across the eight

[4] The Maryland MVA does not assess whether drivers are Hispanic.

**Table 2** Demographics of drivers in Maryland participating in a four-year ignition interlock RCT

| Demographics | | All | Assignment status | |
|---|---|---|---|---|
| | | | Interlock | Control |
| *n* | | 1,927 | 944 | 983 |
| Months in program* | Mean | 22 | 23 | 21 |
| Age at study start | Mean | 40 | 40 | 40 |
| Female | % | 12 | 11 | 13 |
| Race (%) | African-American | 15 | 17 | 14 |
| | Caucasian | 80 | 79 | 81 |
| | Asian | 1 | 1 | 1 |
| | Other/unknown | 4 | 4 | 3 |
| Alcohol-related priors (number) | Mean | 3.3 | 3.3 | 3.3 |
| | 2 Alcohol-related priors (%) | 29 | 29 | 30 |
| | 3 Alcohol-related priors (%) | 35 | 36 | 34 |
| | 4+ Alcohol-related priors (%) | 36 | 35 | 37 |
| | Minimum | 2.0 | 2.0 | 2.0 |
| | Maximum | 14.0 | 14.0 | 11.0 |

*$p<.001$

VDCs, never differing by more than two percentage points. Among all drivers, 83% had a final disposition of conviction, 5% were convicted but were granted probation before judgment, and 12% had only an administrative sanction (because they were not convicted criminally).

It is noteworthy that after enrollment, the interlock drivers remained in their intervention program for an average of 23 months compared to 21 months for the control group, and this difference in average length of participation was highly significant ($t=8.12$, $p < .001$). Therefore, in our survival analyses, comparisons

**Table 3** Distribution of VDCs by assignment status

| | Assignment status | | | | All | |
|---|---|---|---|---|---|---|
| | Interlock | | All | | | |
| VDC of index offense | *n* | % | *n* | % | *n* | % |
| 1 | 61 | 6 | 78 | 8 | 139 | 7 |
| 2 | 371 | 39 | 402 | 41 | 773 | 40 |
| 4 | 58 | 6 | 43 | 4 | 101 | 5 |
| 5 | 259 | 27 | 254 | 26 | 513 | 27 |
| 7 | 154 | 16 | 151 | 15 | 305 | 16 |
| 9 (VDC=3, 6, 8) | 41 | 4 | 55 | 6 | 96 | 5 |
| All | 944 | 100 | 983 | 100 | 1,927 | 100 |

between the interlock and control groups were made as a function of time so that slight differences in average intervention duration between the two groups did not bias estimates of interlock program effects.[5]

Among participants in the interlock group, 56% ($n$=527) had an ignition interlock installed for the duration of their intervention period; 10% ($n$=92) requested and received a waiver; 3% ($n$=30) initially installed an interlock but later had it removed and received a waiver; 9% ($n$=83) initially had a waiver but later installed an interlock; and 22% ($n$=212) failed to comply with program requirements, and their licenses remained suspended. Although the offenders were randomly assigned to the two study groups, those assigned to the interlock program self-selected themselves into the five installed, waiver and failed-to-comply subgroups under real-world conditions. This has implications for the interpretation of subgroup similarities or differences in recidivism, because it is quite likely that members of a given subgroup differ from members of another in more ways than their decision to install or waive the interlock, or fail-to-comply with program requirements.[6]

## Survival analyses

The probability of drivers surviving free of a subsequent alcohol-related violation during the 2-year intervention, 2-year postintervention, and 4-year study periods was estimated using Cox proportional hazards models (Table 4). Being in the control group, being younger, and having more alcohol-related priors significantly increased the hazard rate (or risk) of a subsequent alcohol-related violation for each of the three analysis periods; and African-Americans had a significantly higher hazard rate (or risk) during the 2-year postintervention period. However, none of the other covariates had significant effects during any of the three analysis periods.

While these covariates are of some intrinsic interest, their importance lies in sharpening (or making more precise) the estimates for treatment effects. Controlling for covariates, the interlock program was associated with reductions in the hazard ratios[7] for alcohol-related traffic violations by 36% ($p < .01$) during the 2-year intervention, by 26% ($p = .038$) during the 2-year postintervention period, and by 32% ($p < .001$) during the overall 4-year study period (Table 4). As can be seen, all these reductions were statistically significant (see Appendix for number of events by assignment status and analysis period).

Figures 1, 2, and 3 display the Kaplan–Meier survival curves for interlock and control drivers for the 2-year intervention, 2-year postintervention, and 4-year study periods. In each period, the interlock group had a higher probability of remaining free of a subsequent alcohol-related violation than the control group.

[5] Participants differed slightly in the time they spent in their respective intervention, postintervention, and overall study periods. Therefore, the 2-year and 4-year labels for the three study periods are approximate averages used for convenience in describing the period of interest.

[6] The authors are investigating the influence on recidivism of self-selection into the five subgroups.

[7] These reductions were calculated by dividing 1.00 by the hazard ratio for the control group (which is tantamount to using the negative regression coefficient of the assignment-status flag).

**Table 4** Alcohol-related violations: parameter estimates, standard errors, hazard ratios with confidence limits, and *p* values for predictors in the proportional hazards models by analysis period

| Risk factor | Analysis period | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2-year intervention | | | | 4-year study period | | | | 4-year study period | | | |
| | Parameter estimate* | Standard error | Hazard ratio** (confidence interval) | *p* value | Parameter estimate | Standard error | Hazard ratio (confidence limit) | *p* value | Parameter estimate | Standard error | Hazard ratio (confidence limit) | *p* value |
| Control group | .45 | .16 | 1.57 (1.15, 2.15) | .0046 | .30 | .14 | 1.35 (1.02, 1.79) | .038 | .38 | .11 | 1.46 (1.18, 1.81) | .0005 |
| Age | –.039 | .01 | .96 (.94, .98) | <.0001 | –.027 | .01 | .97 (.96, .99) | <.001 | –.032 | .01 | .97 (.96, .98) | <.0001 |
| Female | .032 | .24 | 1.03 (.64, 1.66) | .8940 | –.18 | .24 | .84 (.52, 1.35) | .458 | –.051 | .17 | .95 (.68, 1.33) | .7680 |
| African-American | –.022 | .25 | .98 (.60, 1.59) | .9307 | .43 | .20 | 1.53 (1.05, 2.25) | .028 | .167 | .16 | 1.18 (.87, 1.61) | .2901 |
| AR priors | .17 | .06 | 1.19 (1.06, 1.33) | .0030 | .14 | .052 | 1.15 (1.04, 1.27) | .007 | .15 | .040 | 1.16 (1.08, 1.26) | <.0001 |
| VDC=1 | .11 | .30 | 1.12 (.63, 2.00) | .7011 | –.68 | .36 | .51 (.25, 1.02) | .057 | –.30 | .23 | .74 (.48, 1.17) | .1978 |
| VDC=2 | –.16 | .20 | .86 (.58, 1.26) | .4296 | –.17 | .17 | .85 (.60, 1.19) | .337 | –.21 | .13 | .81 (.63, 1.05) | .1142 |
| VDC=4 | –.61 | .44 | .54 (.23, 1.29) | .1651 | .02 | .31 | 1.02 (.56, 1.87) | .950 | –.29 | .26 | .75 (.45, 1.24) | .2607 |
| VDC=7 | –.076 | .25 | .93 (.57, 1.50) | .7575 | –.22 | .23 | .80 (.51, 1.25) | .328 | –.18 | .17 | .84 (.60, 1.17) | .2904 |
| VDC=9 (3, 6 or, 8) | .41 | .34 | 1.50 (.77, 2.93) | .2305 | –.31 | .38 | .73 (.35, 1.54) | .410 | –.073 | .26 | .93 (.56, 1.56) | .7823 |

*Parameter estimate for treatment group=–Parameter estimate for control group

**Hazard ratio=$e^{\text{Parameter estimate}}$

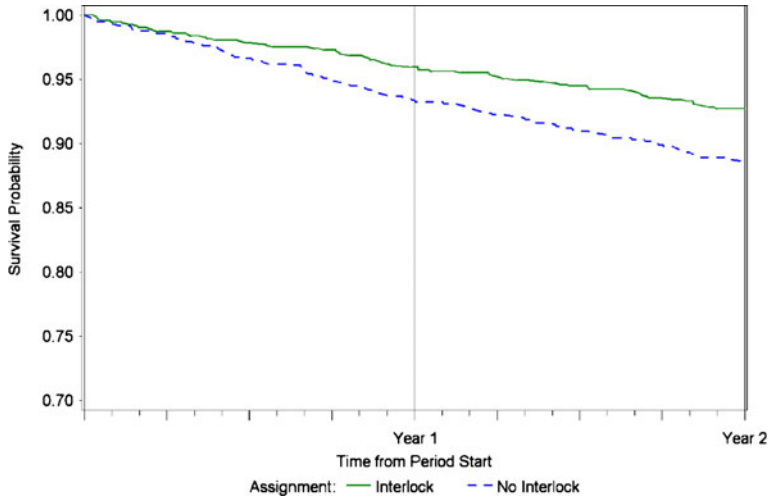


**Fig. 1** Proportion of alcohol-related violation-free drivers by assignment status as a function of time during the 2-year intervention period (Kaplan–Meier estimates for remaining alcohol-related violation-free)

## Relative risks

When we computed relative risks of new alcohol-related traffic violations by direct calculations, the reductions in recidivism associated with the interlock group (compared to its control group) were 31, 24, and 29% across the three study periods, and all were statistically significant (Table 5). These estimates were not adjusted for covariates or for differences in the average duration of intervention, and they are smaller by 2–5 percentage points than the estimates of recidivism reductions of 36, 26, and 32% based on the adjusted proportional hazard model parameters

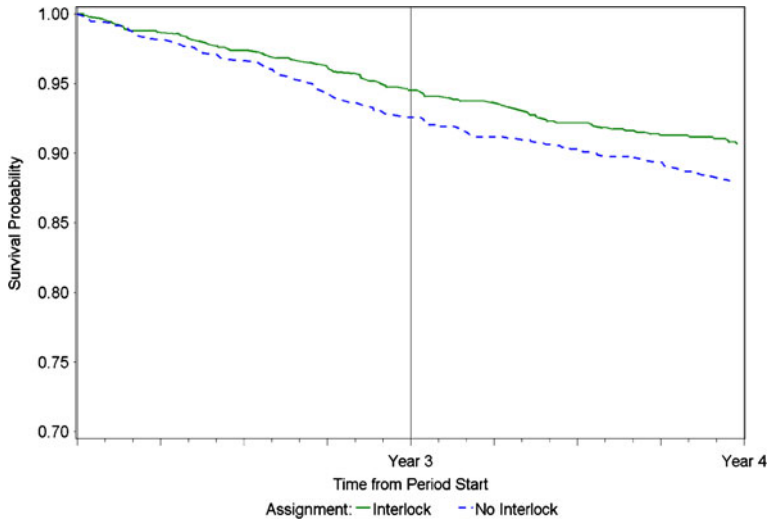


**Fig. 2** Proportion of alcohol-related violation-free drivers by assignment status as a function of time during the 2-year postintervention period (Kaplan–Meier estimates for remaining alcohol-related violation-free)

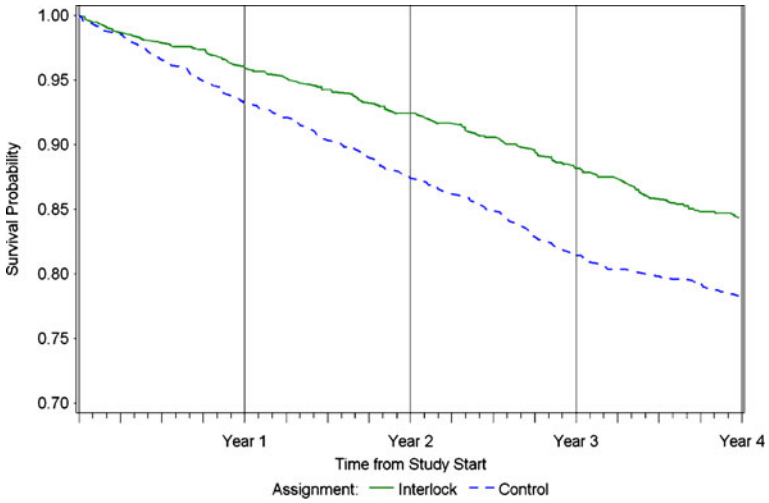


**Fig. 3** Proportion of alcohol-related violation-free drivers by assignment status as a function of time during the entire 4-year study period (Kaplan–Meier estimates for remaining alcohol-related violation-free)

(Table 4). However, both methods show that drivers in the ignition interlock license restriction program had a lower risk of recidivism than drivers in the control group for each study period.

## Discussion

The major purpose of this interlock-focused RCT in Maryland was to determine whether extending the length of the administrative interlock license restriction program among offenders with multiple alcohol-related traffic violations would lengthen its effectiveness by reducing recidivism in the postintervention period. As noted, we compared drivers assigned to the ignition interlock license restriction program with drivers who received the standard and customary conditions of relicensure through the Drinking Driver Monitor Program. Compared to assignment

**Table 5** Relative risk of interlock license restriction drivers having at least one alcohol-related violation compared to control drivers by analysis period

| Analysis period | Relative risk | | 95% confidence limits for direct calculation | | Chi-square | *p* value |
|---|---|---|---|---|---|---|
| | From model[1] | Direct calculation[2] | Lower | Upper | | |
| Intervention (2 years) | .64 | .69 | .51 | .93 | 6.01 | .014 |
| Postintervention (2 years) | .74 | .74 | .58 | 1.00 | 3.86 | ≤.05 |
| Study period (4 years) | .68 | .72 | .59 | .86 | 12.00 | <.001 |

[1] Approximate estimates based on proportional hazard model parameters in Table 4

[2] Estimates directly calculated from driver counts and are not adjusted for demographic factors, prior AR violation history, and length of intervention duration

to the control group, the effect of assignment to the interlock restriction program increased the probability of remaining free of alcohol-related violations during all three study periods, and the hazard ratios indicate that each of these differences in risk was statistically significant.

Both the first ignition interlock randomized trial (i.e., Beck et al. 1999) and our second trial provide strong evidence that ignition interlock license restriction programs (as implemented in Maryland) can reduce alcohol-impaired driving. Although the current study found a smaller reduction in recidivism during the intervention period, it found a significant reduction in recidivism (i.e., a carryover effect) after the interlock restriction was no longer required. In the following section, potential explanations for these discrepancies between the two RCTs are discussed, and reasons for the postintervention carryover effect in the current study (a possible result of deterrence) are considered.

## Similarities and differences between the two Maryland RCTs

In several respects, the two trials were similar. Both were conducted under the auspices of the Maryland MVA, with administrative rather than judicial oversight. Both used an intent-to-treat design with random assignment. To be eligible for randomization, offenders had to petition for relicensure and be approved by the MVA after complying with sanctions associated with their license suspension. Participation was limited to offenders with more than one arrest for an alcohol-related traffic violation. Every offender randomly assigned to the interlock program received an interlock-restricted driver's license, except the subgroup that remained on license suspension because they failed to agree to the terms of participation. The control intervention consisted of participation in Maryland's Drinking Driver Monitor Program in which probation officers monitored compliance with required alcohol treatment and sobriety.

The only difference between the two trials, except for their timing, was the length of the intervention and postintervention periods (2 years each in the second trial compared to 1 year each in the first trial). Despite the similarities, the two trials showed major differences in their rates of recidivism for alcohol-related traffic violations that are not easily explained. First, during the 2-year intervention period, the interlock group in the second RCT showed a much smaller reduction in recidivism (36%), compared to its control group, than the interlock group in the first RCT showed during their 1-year intervention period (64%). Second, during the 2-year postintervention period, the interlock group in the second RCT showed a statistically significant 26% reduction in recidivism, compared to its control group. Yet, during the 1-year postintervention period in the first RCT, the interlock group had a recidivism rate that was 33% higher than its control group, although this difference was not significant.

It is interesting that for the combined 4 years of the second RCT, the 32% reduction in recidivism for the interlock group compared to its control group was quite similar to the 36% reduction in recidivism for the interlock group compared to its control during the combined 2 years of study in the first RCT. However, this similarity resulted from quite different patterns of recidivism across the intervention and postintervention periods in the two RCTs.

Of particular interest is the much smaller reduction in recidivism that occurred among the interlock group during the intervention period in the second RCT than the first. We considered several possible explanations: the longer intervention period in the second RCT, the somewhat larger proportion of failed-to-comply offenders among those assigned to the interlock program in the second trial compared to the first, possible differences in overall DUI/DWI enforcement practices during the two trials, and differential monitoring of interlock program participants by the MVA in the two studies.

Regarding the 2-year versus 1-year intervention periods, the Kaplan–Meier survival curves in Fig. 1 indicate that the differences in recidivism-free survival between the interlock and control groups became larger rather than smaller over the 2-year intervention period. With respect to subgroup differences, in the second RCT, 22.5% of offenders assigned to the interlock program remained license-suspended because they failed to agree to the terms of participation, compared to 14% of offenders in the first trial. During the intervention periods in both trials, the failed-to-comply subgroup showed higher recidivism and poorer violation-free survival (compared to the control group) than did other offenders in the interlock program. Yet, the greater proportion of failed-to-comply offenders in the second trial is unlikely to be the major cause of recidivism differences between the two RCTs, for two reasons: (1) The relative risk of recidivism for the failed-to-comply subgroup compared to the control group was substantially higher in the second RCT than it was in the first (1.31 vs. .76); and (2) compared to the control group, the installed subgroup, which had approximately equal prevalence in the two trials, also showed a higher relative risk during the second than first RCT (.49 vs. .38).

It is quite possible that overall enforcement of laws related to impaired driving changed from the first RCT study period to the second, but determining whether and how such changes (e.g., the change in legal BAC limits from .10 to .08 on October 1, 2001) might have differentially affected recidivism rates among the interlock and control groups would require a complex study involving comprehensive field work. However, we already know that there were substantial differences between the two trials in the way participants in the interlock program were monitored.

In the first RCT, MVA staff closely monitored and strictly enforced program compliance; noncompliers were emergency-suspended or referred to the Maryland Medical Advisory Board for further evaluation. By the time of the second trial, MVA staff assigned to the interlock program had changed completely, and there was practically no monitoring or enforcement of program compliance (Madigan 2007; Office of Legislative Audits 2007). Instead, MVA staff focused on monitoring the installation of interlocks, their authorized removal, and the issuance of conditional license restrictions. Offenders freely violated program requirements with essentially no repercussions. Even egregious violations (e.g., disconnecting the ignition interlock, refusing rolling retests, or logging numerous breath alcohol tests above the legal BAC limit) by the installed subgroup during the program remained unsanctioned. At the end of their 2-year intervention period, participants were sent a congratulatory letter for successfully completing the interlock program and their driver's licenses were fully reinstated despite other violations unrelated to the interlock program.

We believe that this decisive change in MVA monitoring and enforcement practices from the first to second RCT is the major reason why the interlock group

showed smaller reductions in alcohol-related recidivism (relative to the control group) during the intervention period in the second RCT than the first. From the perspective of criminal behavior and its deterrence, the weaker monitoring explanation in the context of alcohol-impaired driving and ignition interlocks is congruent with routine activity theory (Bouffard et al. 2007; Gruenwald et al. 1996). According to this theory, the probability of a criminal event increases when (in the course of regular, everyday activities) there is a convergence among motivated offenders, suitable targets, and the absence of capable guardians (Cohen and Felson 1979; Felson 2002). The reverse is also true. Crimes can be prevented when the presence of motivated offenders and suitable targets are decreased and capable guardians are increased.

The first element of routine activity theory is rarely tested and assumes the presence of motivated offenders. Multiple offenders who repetitively disregard DUI/DWI laws and drive after drinking are essentially involved in routine alcohol-impaired driving that is reinforced by the low probability of arrest (Anda et al. 1986; Beitel et al. 1975; Borkenstein 1974; Hingson 1995; Voas and Hause 1987; Zador et al. 2000); low detection rates, even during special enforcement operations such as sobriety checkpoints (Ferguson et al. 1995; Jones and Lund 1986); and few harmful repercussions such as crashes. Studies clearly indicate that a substantial proportion of multiple DUI/DWI offenders are motivated to drink because they are dependent on alcohol (Dawson 1999; Perrine 1990; Voas 2001; Wiliszowski et al. 1996), that they are motivated to drive after drinking because their last drink was likely to have been in a bar or restaurant (McKnight 1993) to which they had driven, and because alcohol-impaired drinkers misinterpret cues of intoxication (Jones and Lacey 2000) and tend to be over-confident in their ability to drive safely while intoxicated (Caudill et al. 1990).

Suitable targets, the second element of routine activity theory, can be victims, property, or a criminal activity. In the case of DWI, the suitable target activity is the criminal act of driving above the legal BAC limit (Gruenwald et al. 1996). Vehicles equipped with an ignition interlock prevent that criminal activity through target hardening—they create an environment that is not conducive to the illegal behavior because a vehicle will not start if the driver is impaired by alcohol. The interlock license restriction also can limit available targets but not as overtly as the interlock device itself. Although the license restriction prohibits drivers from operating vehicles devoid of interlocks, its effectiveness depends on the driver to abide by the restriction or on law enforcement to detect and sanction drivers who fail to comply.

The third element, lack of capable guardians, pertains to the availability of people or devices that can deter a criminal event. Natural guardians to prevent DUI/DWI are police officers on patrol or assessing sobriety at checkpoints. However, guardians are not limited to persons and can include objects that can prevent crime (Felson 2002), such as the ignition interlock. This device prevents alcohol-impaired driving without the need for direct human intervention by interrupting the impaired driver's routine pattern of drinking and driving. In preventing use of the vehicle in which it is installed, the interlock serves as a guardian for individuals who mistakenly believe they are below the preset BAC limit. The interlock license restriction also can remind potential illegal drivers that the police have authority to serve as guardians of the public. Moreover, both of these constraints can provide opportunities for the

significant others of participants in the interlock program (e.g., spouses, partners, and friends) to serve as guardians by engaging in informal social control that reinforces compliance behavior and counters noncompliance.

## Carryover effect

Another difference between the two randomized trials is the continued reduction in alcohol-impaired driving evident among drivers assigned to the interlock license restriction program in the second RCT compared to their control group. Unlike the first RCT, drivers assigned to the interlock program in the second RCT experienced a positive carryover effect after the intervention period ended. Learning theory provides a possible explanation for this discrepancy. One of the key assumptions of learning theory is that human behavior is flexible (Tarde 1903 [1963]). If human behavior is indeed flexible, it should be possible for a behavior such as alcohol-impaired driving to be unlearned. Just as impaired driving becomes a routine activity when drivers learn that they can drink and drive freely because of the low probability of arrest and low detection rates, drivers may also unlearn that behavior.

Akers (1985) social learning theory includes two concepts that may be applicable to the learning and unlearning of alcohol-impaired driving: differential reinforcement (i.e., the balance between anticipated or actual rewards and the punishments that follow or are consequences of behavior) and conditioning. Alcohol-impaired drivers who are not detected may repeat the behavior because they believe that they can drive without being apprehended and are "rewarded" by the completion of a successful driving trip. After numerous undetected alcohol-impaired driving trips, a driver can "learn" that it is safe to drive after drinking. The ignition interlock, however, should condition drivers to expect that the vehicle will not start if their breath alcohol concentration is at or above the preset limit. For each breath test taken and failed, the driver is "punished" and is unable to start his or her vehicle. It is, therefore, reasonable to hypothesize that drivers of cars with installed interlocks will eventually be conditioned to anticipate these reinforcers instead of those that encourage impaired driving.

In essence, the ignition interlock device incorporates operant conditioning (Skinner 1974), which is an important component of programs that attempt to change or modify behavior (Cullen and Gendreau 2000) through reinforcers or consequences. The balance between positive reinforcement if the breath sample is below .025 BAC and negative reinforcement if the sample is at or above .025 BAC may condition driver behavior over time. In the second RCT, repetition of these reinforcers (for those who had an interlock installed) over a 2-year rather than 1-year period may have contributed to the continued reduction in recidivism (the carryover effect) during the postintervention period among drivers assigned to the interlock program compared to their controls.

## Program acceptance

Many investigators have suggested that suspended DUI/DWI offenders would rather remain license-suspended than accept an administrative interlock program as a condition of early license reinstatement (Bjerre 2003; Beirness et al. 2008; Compton

and Hedlund 2007; DeYoung 2002; DeYoung et al. 2004; Lucke et al. 2001; NHTSA 2009; Popkin et al. 1992; Raub et al. 2001, 2003; Roth et al. 2007a, b; Tippetts and Voas 1998; Voas et al. 1999, 2002). Yet, data from this RCT showed high levels of interlock-program acceptance; 78% of offenders accepted enrollment in the 2-year interlock program as a condition of relicensure.

A recent study of Florida's mandatory administrative interlock program for first and multiple offenders, which began in 2002, indicates that 93% of those eligible actually installed the interlock as a means of obtaining conditional license reinstatement, in preference to continued (possibly lifelong) license suspension (Voas 2009). In reality, however, this figure may be as low as 43% depending on definitions of eligibility and acceptance. A high proportion of offenders who had completed hard suspension apparently preferred to remain license-suspended than to fulfill remaining requirements (e.g., paying fines for unpaid traffic tickets or paying child support) that would make them eligible for interlock installation and conditional relicensure. Such dilatory behavior could be considered nonacceptance of the interlock program, even in the face of potentially infinite license suspension and illegal driving. It can be argued that the Florida law presents draconian alternatives to interlock installation that contribute to the "acceptance" rate of 93%, and that the eventual installers are a highly select group of offenders. Yet, when their ignition interlocks were removed and drivers obtained full relicensure, their recidivism rate rose to the rate for suspended drivers.[8]

Regardless of the predilections of DUI/DWI offenders regarding ignition interlocks, the preferences of the American public may ultimately prevail. A recent national survey by the Insurance Institute for Highway Safety shows that the American public likes the idea of using "advanced technology… to prevent alcohol-impaired driving" (McCartt et al. 2009: 1). Two out of three respondents thought this was a good or very good idea, assuming the technology was available. Among the sample as a whole, 42% of respondents who regularly drive said they "would want an alcohol detection device in their next vehicle," assuming it was available and reasonably priced (McCartt et al. 2009: 1). Even among those who admitted that they might have driven when they were over the legal alcohol limit, 55% felt it was a good or very good idea to equip all cars with advanced alcohol detection devices.

## Conclusions

### Key findings

All factors considered, the findings from this RCT lead to a set of statistically validated conclusions about the potential effectiveness of an administrative interlock license restriction program. First, extending the intervention period to 2 years was associated with significant reductions in recidivism during the 2-year postintervention

[8] Oddly, the Florida program requires that vehicle ignitions block drivers from starting their cars when their BAC levels are at .051 and higher. This level is considerably higher than the .025 BAC recommended by the NHTSA and specified by most states, including Maryland. In this respect, Florida's law is not draconian because drivers can drink some alcohol and still legally drive their interlock-equipped vehicles.

period. Second, even though only 56% of eligible offenders had the ignition interlock installed for the duration of their intervention period, interlock program participants as a whole showed substantial and significant reductions in their rates of recidivism compared to the randomly selected standard-treatment control group.

These findings indicate that the interlock restricted license helped curtail illegal driving by participants in the program who waived installation of the interlock for all or part of the intervention period. It is also important to note that we tested an administrative interlock program, which generally permits faster sanctions for noncompliance (e.g., license suspension) than would a judicially managed program, because reasonable suspicion by law enforcement, and not a conviction by a court, begins the sanctioning process. In summary, we believe that it was the combination of these factors, and not just installation of the ignition interlock device itself, that contributed to the overall effectiveness of the interlock program tested in the RCT described in this article.

## Future research

Our data have also led to some informed inferences that have yet to be fully validated. First, the clearly visible interlock license restriction may well have contributed to the positive results by constraining noncompliant behavior of participants who installed or waived the interlock, but the effectiveness of this restriction was not tested as a distinct intervention. Additional data, such as interviews with drivers, would be necessary to provide evidence to confirm or refute this hypothesis. Second, there are strong reasons to believe that closer monitoring explains the larger reductions in recidivism during the intervention period in the first trial than the second. To more firmly establish the validity of this explanation, we conducted and are analyzing results of a third RCT that compared the effects of closer and standard monitoring. Third, the trial required offenders to complete all prelicensure sanctions (including treatment) before becoming eligible for relicensure and the interlock program. This requirement may have heightened the probability of enduring attitudinal and behavior change, but we did not test that possibility.

During the intervention period, subgroups of offenders who initially agreed to comply with interlock program requirements had lower risks of recidivism (relative to the control group) than the subgroup who failed to accept program requirements. It, therefore, appears that program acceptance positively contributes to program effectiveness. However, validly testing the effects of acceptance poses a challenge because factors that influence acceptance of interlock programs also are likely to influence future recidivism. Given a very large interlock sample and detailed information about program participants, it would be possible to correct for self-selection bias by statistical methods (e.g., analysis of covariance or propensity analysis), but these analyses were not conducted and are not planned.

As a caution, it should again be noted that before enrollment, all offenders were required to complete their license suspension period and relevant sanctions, apply for license reinstatement, and be approved for relicensure by the Maryland Medical Advisory Board.

Because the same selection bias applied to both the interlock and control groups, it should not have affected estimates of program effectiveness, but these enrollment

requirements clearly limit the generalizability of conclusions. Our findings are most applicable to states in which criteria for relicensure of multiple offenders are similar to those in Maryland.

As indicated in our introduction, interlock programs are increasing across the United States, and some jurisdictions have included first-time offenders among eligible participants (Insurance Institute for Highway Safety 2009)—namely, offenders whose driver record indicates that the index offense is his or her first recorded alcohol-related traffic violation. The RCT we have described in this paper is unique in showing a statistically significant reduction in recidivism among drivers with multiple offenses after the intervention period ended and after the interlock devices and accompanying license restrictions were removed. However, there are still lessons to be learned about how best to improve and use this technology—for which offenders, for what period of time, and the extent to which cost considerations affect the effectiveness of interlock programs by constraining an agency's capacity to monitor the behavior of program participants.

**Acknowledgements** This research was funded by Contract DTNH22-97-C-05121 from the National Highway Traffic Safety Administration (NHTSA) and Grant R01 AA11897 from the National Institute on Alcohol Abuse and Alcoholism (NIAAA). The views expressed in this paper are those of the authors and do not necessarily reflect the positions or polices of the funding agencies. The authors would like to thank the Editor and three anonymous reviewers for insightful comments on the manuscript.

## Appendix

**Table 6** Events (alcohol-related violations) by intervention period*

| | Intervention (2 years) | Postintervention (2 years) | Overall (4 years) |
|---|---|---|---|
| Interlock ($n$=944) | 66 | 78 | 144 |
| Control ($n$=983) | 99 | 110 | 209 |
| Total | 165 | 188 | 353 |

* Drivers in each study group may have had more than one alcohol-related violation during a particular 2-year study period or the study as a whole

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