

Effectiveness of Ignition Interlocks for Preventing Alcohol-Impaired Driving and Alcohol-Related Crashes

A Community Guide Systematic Review

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Abstract: A systematic review of the literature to assess the effectiveness of ignition interlocks for reducing alcohol-impaired driving and alcohol-related crashes was conducted for the *Guide to Community Preventive Services (Community Guide)*. Because one of the primary research issues of interest—the degree to which the installation of interlocks in offenders’ vehicles reduces alcohol-impaired driving in comparison to alternative sanctions (primarily license suspension)—was addressed by a 2004 systematic review conducted for the Cochrane Collaboration, the current review incorporates that previous work and extends it to include more recent literature and crash outcomes. The body of evidence evaluated includes the 11 studies from the prior review, plus four more recent studies published through December 2007. The installation of ignition interlocks was associated consistently with large reductions in re-arrest rates for alcohol-impaired driving within both the earlier and later bodies of evidence. Following removal of interlocks, re-arrest rates reverted to levels similar to those for comparison groups. The limited available evidence from three studies that evaluated crash rates suggests that alcohol-related crashes decrease while interlocks are installed in vehicles. According to *Community Guide* rules of evidence, these findings provide strong evidence that interlocks, while they are in use in offenders’ vehicles, are effective in reducing re-arrest rates. However, the potential for interlock programs to reduce alcohol-related crashes is currently limited by the small proportion of offenders who participate in the programs and the lack of a persistent beneficial effect once the interlock is removed. Suggestions for facilitating more widespread and sustained use of ignition interlocks are provided.

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Introduction

Drivers convicted of driving while impaired (DWI) present a high risk to other highway users. Hedlund and Fell¹ found that offenders convicted of DWI are 4.1 times more likely to be involved in a fatal crash while intoxicated by alcohol than are average licensed drivers. Further, 35% to 40% of all fatally injured drinking drivers are estimated to have had at least one prior DWI offense.^{2,3} For the first two thirds of the 20th century, the traditional penalties assessed for a DWI conviction were jail, fines, and license suspension. Of these, license suspension has provided the strongest and most consistent evidence of effectiveness in reducing recidivism.^{4–6} Nonetheless, both self-reports⁷ and covert surveillance⁸ of suspended DWI offenders indicate that many of these drivers continue to drive without licenses or insurance,

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and that they often continue to do so even after becoming eligible for license reinstatement.⁹

Use of Vehicle Sanctions to Reduce Illicit Driving

Given the evidence that suspension alone does not prevent DWI offenders from driving illicitly, state legislatures have enacted various measures that keep impaired-driving offenders from accessing their vehicles, such as vehicle impoundment and immobilization laws^{10–12} and vehicle forfeiture laws.¹³ Although there is evidence that such actions reduce recidivism, they may have potential adverse effects on innocent family members, and therefore have not been widely adopted for a broad range of offenders. A less disruptive approach to reduce DWI recidivism is to require installation of a device on the vehicle that prevents a driver impaired by alcohol from operating the vehicle.

History of Interlock Development and Use

The first efforts to develop devices to prevent vehicle operation by intoxicated drivers grew out of human performance research. From this work, some prototype devices, such as a “Quick Key” unit that tested the driver’s reaction time, were developed for vehicles.¹⁴ However, the large variation in human performance resulted in a substantial number of false-positive signals. Subsequent systems were designed to assess intoxication more directly, using a dashboard-mounted breathalyzer device that prevents the vehicle from starting if the driver’s blood alcohol concentration (BAC) is above a predefined limit. The first ignition interlock device that used BAC testing was introduced in 1970. However, it did not operate reliably under all environmental conditions, and lacked several provisions that proved necessary to prevent circumvention.

Beginning in the 1990s, a “second generation” of interlocks¹⁵ was introduced, which added several features that made circumvention more difficult. These features include:

- Hum tone recognition—which requires training to make the sensor work, and prevents the driver from using untrained substitutes,
- Filtered air detection—which prevents blowing through a device that filters out the alcohol,
- Blow abort—which detects air samples that are too small, and
- Random running retest—which prevents drinking while the engine is running.

Coupling these features with a requirement that the interlocked vehicle be brought in for service every 30 days

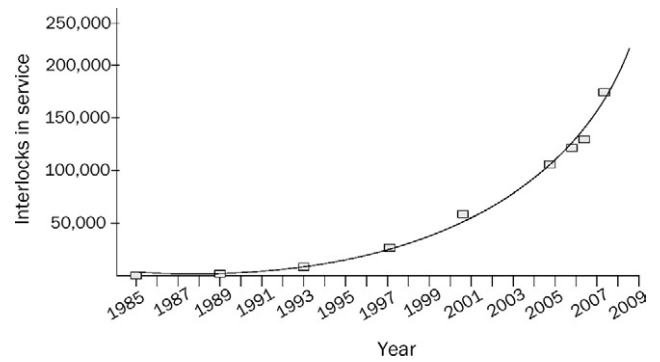


Figure 1. Interlock growth in the U.S. through 2009, data with polynomial fit (adapted from Marques, 2009¹⁸)

resulted in units for which undetected circumvention was very difficult.¹⁶ These features were integrated into a model for state interlock standards by the National Highway Traffic Safety Administration (NHTSA) in 1992. Although these standards minimized the opportunity for offenders to drive their interlock-equipped cars after drinking, they could not prevent offenders from circumventing the system by illegally driving different vehicles without interlocks. However, the existing evidence¹⁷ suggests that the availability of a non-interlock vehicle did not greatly reduce the effectiveness of interlocks for preventing alcohol-impaired driving.

The advent of “second generation” interlock units and the 1992 NHTSA standards stimulated a dramatic increase in their use in the U.S. (Figure 1), amounting to an estimated 200,000 units by 2009.¹⁸ Nevertheless, NHTSA’s model specifications still showed two limitations in the interlock hardware: (1) definitive identification of the person blowing into the unit was not available and (2) although circumvention was difficult, detection of any attempt to circumvent the unit was delayed until the next scheduled maintenance inspection of the interlock. Since then, interlock manufacturers have been working to improve methods for identifying the user and for ensuring that an attempt to bypass the unit will cause it to shut down unless it is quickly brought in for a maintenance inspection (~48 hours).

Types of Interlock Programs and Their Influence on Interlock Use

One of the most important limiting factors for the public health impact of interlock programs is the relatively small number of offenders who participate in such programs. Despite the continuing growth of interlock use, only a small fraction of the approximately 1.4 million people arrested for DWI annually in the U.S. use them. This apparently low usage rate is partly due to the failure to convict some of the arrested offenders, and it also reflects

the policy in most states of confining their programs to the 400,000 to 500,000 multiple offenders apprehended each year. Furthermore, contrary to early expectations, many DWI offenders prefer license suspension to interlock installation; generally, less than 10% of eligible offenders enter interlock programs.¹⁹

The specific features and procedures of interlock programs vary both among states and among jurisdictions within states. One of the key features of interlock programs in the U.S. is the type of legal authority that they operate under:

1. The judicial authority to impose suitable sanctions under common law;
2. State laws specifically providing for the use of interlocks as a sanction for DWI or for driving while suspended (DWS); and
3. The administrative authority of the state motor vehicle department to regulate driver licensing.

These programs also vary with respect to who is eligible, when interlocks are installed (i.e., after arrest versus after sentencing), and whether judges or offenders have discretion over offering or participating in interlock programs. All of these features have the potential to influence both the number and characteristics of offenders who participate in the programs, and thus their public health impact.

Judicial Interlock Programs

The earliest interlock programs were implemented by individual judges applying the interlock as one sanctioning option. Under such programs, court orders to install interlocks often were not processed by the department of motor vehicles (DMV). Consequently, these required sanctions were not on the license records, and officers who stopped offenders would not be alerted to check for the interlocks.

Based on some evidence that these early programs were successful in reducing recidivism among the small number of people who had interlocks installed,²⁰ some states passed legislation that provided judges with explicit authority to impose interlocks at their discretion. This produced only a modest increase in the number of offenders using interlocks because the courts continued to enlist only 10% or less of eligible offenders.²¹

In part, this low penetration of interlock programs stimulated the passage of mandatory laws that required judges to place offenders convicted of multiple DWIs in interlock programs. However, such laws conflicted with other state legislation mandating hard license suspensions—which prohibit any driving—for second-time offenders. Thus, courts were mandated to require interlocks on vehicles that offenders could not legally drive; few courts

complied with this mandate.^{22,23} A provision of the Federal Transportation Equity Act for the 21st Century required states to suspend the licenses of second-time offenders for at least 1 year.²⁴ That law has since been changed by the Congress to require only 3 months of suspension.

Administrative Interlock Programs

Several states (e.g., California, West Virginia) have enacted laws administered by state DMVs that allow offenders who have interlocks installed to drive during a period in which their driving licenses would otherwise be fully suspended. More recently, in part because of the requirements of the Federal Transportation Equity Act, states have begun to implement laws that require installation of an interlock as a prerequisite for license reinstatement. Two types of such legislation have been implemented. Some states require a period of interlock installation before license reinstatement, but the offender can delay reinstatement during the period the interlock would be required and thereby avoid installing the device. An alternative implemented in other states, such as Florida, is to require a period of interlock installation no matter how long the offender delays, thus making it impossible to avoid the requirement if the offender is ever to be relicensed. A potential problem for these postreinstatement programs is that many DWI offenders delay reinstatement for 1 year or more and up to one third never reinstate.^{9,25}

Efforts to Increase Interlock Use

Several recent efforts have been made to develop programs that better address barriers limiting the uptake of interlocks. The goal of these efforts is to increase the number of offenders who drive interlock-equipped vehicles, to realize more fully the potential population-level effects of interlocks on alcohol-impaired driving and alcohol-related crashes. Primary strategies involve increasing the number of offenders eligible for interlocks, increasing the desirability of participating in the program, and increasing the negative consequences of failing to participate in the program.

Some states have developed programs that allow or require the installation of interlocks after an arrest (as opposed to conviction) for DWI. This minimizes the period of license suspension, during which offenders may become accustomed to driving illegally,⁸ thus leading them to devalue the opportunity for legal driving afforded by the interlock program. For example, Texas has a judicial program that requires some offenders to have an interlock installed before posting bail after arrest. In 2003, New Mexico created a voluntary administrative program that allows any driver whose license is sus-

pending for an alcohol offense to receive a license to operate an interlock-equipped vehicle simply by appearing at the DMV with an interlock-equipped vehicle.²⁶

New Mexico has made numerous other changes in its interlock program to increase its penetration. In 2003, the judicial discretionary law was replaced by one that mandated interlocks for all first-time offenders convicted of aggravated DWI and all multiple offenders. In 2006, a law mandating interlocks for *all* DWI offenders was implemented, greatly expanding the number of offenders eligible for the program. This law includes provisions for subsidized installation and monitoring of interlocks for low-income offenders. Although implementation of each law appears to have produced an increase in the number of interlocks in use, by 2006, only 25% of New Mexico drivers apprehended for a DWI offense had been placed on the interlock.

The modest success of the efforts to increase the penetration of interlocks in New Mexico illustrates the limitations of such efforts. Some of these limitations are inherent in the judicial system itself. In New Mexico, roughly one third of those arrested for DWI are not convicted of that offense. Another problem relates to loopholes in the legislation that allow offenders who claim not to have vehicles or who agree not to drive to avoid interlock installation. Those who use this loophole with the intention of driving while suspended can then simply drive an unregistered vehicle or one registered to another person. This “no-car problem”²³ is perhaps the major barrier to extending interlocks to all convicted offenders.

Efforts continue to develop interlock programs that minimize the opportunities for offenders to avoid their use. One such approach is to apply more-severe sanctions for people who opt out of an interlock program. For example, one study¹⁹ found that if electronically monitored home arrest was presented as an alternative to interlock installation, approximately two thirds of DWI offenders chose to have interlocks installed.

Goals of This Review

One of the primary research issues of interest to the review development team was the degree to which the installation of interlocks in offenders' vehicles reduces alcohol-impaired driving in comparison to alternative sanctions (primarily license suspension). Because this question was addressed thoroughly by a recent systematic review conducted for the Cochrane Collaboration,²⁷ the previous work was not replicated. The current review builds on the earlier Cochrane review by incorporating more recent studies and placing the findings from that review in a broader public health context. Specifically, it (1) addresses the effects of ignition interlock installation

on motor vehicle crashes and (2) discusses various key features of interlock programs that could increase their effectiveness for improving population health.

Methods

This review was conceptualized and conducted by a systematic review development team consisting of subject matter experts in traffic safety and systematic review methodology, under the oversight of the independent, nonfederal Task Force on Community Preventive Services (the Task Force) and using the methods of the *Guide to Community Preventive Services (Community Guide)*. *Community Guide* methods for conducting systematic reviews and linking evidence to effectiveness are described in print elsewhere²⁸ and on the *Community Guide* website (www.thecommunityguide.org/about/methods.html). In brief, for each *Community Guide* review topic, a systematic review development team representing diverse disciplines, backgrounds, and work settings conducts a review by (1) developing a conceptual approach to identify, organize, group, and select interventions for review; (2) developing an analytic framework depicting interrelationships among interventions, populations, and outcomes; (3) systematically searching for and retrieving evidence; (4) assessing and summarizing the quality and strength of the body of evidence of effectiveness; (5) translating evidence of effectiveness into recommendations; (6) summarizing data about applicability (i.e., the extent to which available effectiveness data might apply to diverse population segments and settings), economic impact, and barriers to implementation; and (7) identifying and summarizing research gaps. All data abstraction and quality scoring is conducted by two independent reviewers.

Conceptual Model

Figure 2 illustrates the hypothesized causal pathway from the implementation of ignition interlock programs through the outcomes of interest for judging effectiveness, specifically alcohol-impaired driving and its consequences—alcohol-related crashes and the resulting fatal and nonfatal injuries. Solid lines reflect relationships assessed in this review, and dotted ones reflect those that are simply hypothesized. It should be noted that although alcohol-impaired driving (i.e., recidivism) was a primary variable of interest in this review, it can be assessed by only the proxy measure of re-arrest for alcohol-impaired driving (or for related infractions).

The initial step in this causal pathway is that ignition interlock programs will result in the installation of interlocks in offenders' vehicles. As discussed above, the strength of that causal relationship is likely to be a function of the characteristics of the interlock programs. If used properly, interlocks will prevent alcohol-impaired driving and its consequences. Installation of interlocks may also have two secondary effects with important public health consequences. First, because they allow legal driving, they can be expected to increase the number of miles driven by participants in interlock programs relative to offenders who have had their licenses suspended, potentially increasing crashes that are not alcohol-related, which may result in injuries. Second, by forcing participants to choose between drinking and driving, interlocks provide a consistent behavioral consequence that may discourage drinking in the short term. Interlocks also have substantial potential for synergistic use with programs to address offenders' underlying alcohol dependence and abuse problems. These potential influences on alcohol consumption could contribute to reductions in

alcohol-impaired driving and its consequences in both the short and long term.

Search for Evidence

In the interest of efficient use of resources, *Community Guide* methods allow for the incorporation of systematic reviews conducted by other groups into the body of evidence that is used to assess the effectiveness of interventions. The primary criteria that must be met to incorporate such reviews are that they conceptualize the intervention of interest

in a similar manner to that of the review team; conduct a thorough and clearly systematic literature search; and provide results in a format and level of detail that adequately addresses one or more of the key research questions identified by the review team. In such cases, supplementary searches for and evaluations of evidence may be conducted to answer other issues of importance to the review team and the Task Force on Community Preventive Services.

One of the primary research questions identified by the team was the degree to which the installation of interlocks in offenders' vehicles reduces alcohol-impaired driving compared with alternative sanctions. Because an initial search identified a recent systematic review²⁷ conducted for the Cochrane Collaboration that met the *Community Guide* criteria for incorporating an existing review, no further database search was conducted for this review. Instead, a focused systematic search of sources likely to provide a high yield of relevant studies was conducted to obtain information to fill the gaps in the Cochrane review. The results from the Cochrane review were considered along with information from subsequent studies that were identified by hand-searching three key outlets for research on the effectiveness of ignition interlocks—the journal *Traffic Injury Prevention*; publications of the International Council on Alcohol, Drugs, and Traffic Safety's Working Group on Alcohol Ignition Interlocks; and the proceedings of the International Symposia on Ignition Interlocks. These hand-searches covered the period of March 2003 through December 2007. Inclusion criteria for papers identified in the hand-search were identical to those used in the previous review, with the exception that studies evaluating motor vehicle crashes were also eligible for inclusion.

Information on motor vehicle crashes and other variables of interest (e.g., participation rate in the interlock program; program eligibility criteria) was abstracted from the papers identified in both the Cochrane review and those subsequently identified in the hand-search. Inclusion criteria for papers identified in the hand-search were identical to those used in the previous review, with the exception that studies evaluating motor vehicle crashes were also eligible for inclusion. Four unique studies in addition to those from the Cochrane review were identified in the hand-search, and one

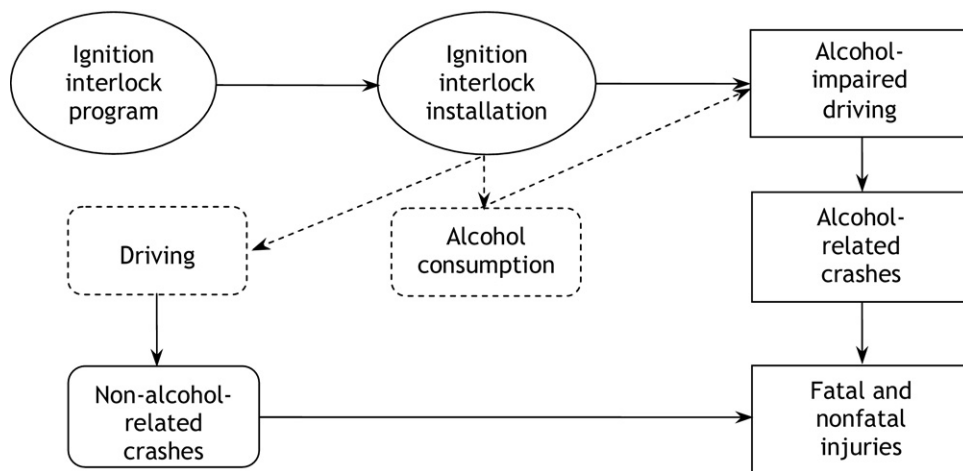


Figure 2. Conceptual model for the causal effects of ignition interlock programs on alcohol-impaired driving and its consequences. (Ovals indicate interventions; rectangles with rounded corners indicate mediators or intermediate outcomes; and rectangle indicates health outcomes)

study from the Cochrane review included information on motor vehicle crashes.

Effect Measurement and Synthesis of Results

The majority of the studies included in this review reported intervention effects as risk ratios (RRs, usually derived from a 2×2 contingency table of events occurring at any time over the entire evaluation period) or as hazard ratios (HRs, usually derived from survival analyses). Because HRs address individual differences in “time at risk” due to factors such as when interlocks were installed or removed, and whether offenders were re-arrested during the study period, HRs were reported when possible. Both of these metrics can be similarly interpreted as reflecting the percentage change in risk of re-arrest attributable to the interlock intervention. Thus, to facilitate synthesis across studies, these effect metrics were treated as equivalent for the purpose of calculating summary statistics. The results from the Cochrane review are summarized with descriptive statistics, specifically medians and interquartile intervals. The additional results from papers identified in the hand-search are presented separately.

Results. Part I. Intervention and Study Characteristics

Appendix A presents the key intervention and study characteristics for the studies included in this review,^{21,23,29–43} as well as summaries of their findings. Although several program characteristics varied widely across studies (e.g., the type of program), all or most programs shared several key characteristics. They generally

- were applied to offenders who are at high risk of recidivism, either due to multiple offences or, for first-time offenders, high blood alcohol concentration (BAC) at arrest (generally >0.15 g/dL);

- were offered as an option in exchange for a reduced length of license suspension (and compared with drivers with suspended licenses as a comparison); and
- required interlock installation for periods ranging from 5 to 36 months (medians of 7.5 months for first-time offenders and 18 months for repeat offenders).

Reported participation rates varied dramatically across the programs evaluated in the reviewed studies, from less than 1% of offenders³⁹ to 64% of offenders³⁰ (median: 13%). This large variability partly reflects the use of different denominators (e.g., interlock-eligible offenders versus offenders who actually were offered interlocks).

The majority of reviewed studies prospectively followed cohorts of offenders who had interlocks installed in their cars, and compared them to cohorts of offenders who did not have interlocks and whose licenses were suspended instead. Because several nonrandom factors can influence whether a given offender has an interlock installed, such studies have a substantial risk of producing biased effect estimates resulting from noncomparable intervention and comparison groups. Several studies included evidence suggesting at least some degree of noncomparability between groups. In particular, the interlock groups tended to be older,^{31,35,39} drive more,³² have higher incomes,^{33,39} and have more offenses or more serious offenses.^{33,41}

Results. Part II. Evidence of Effectiveness

Effects of Ignition Interlock Installation on DWI Recidivism

Results from the studies in the Cochrane review. The Cochrane review²⁷ identified 11 studies that evaluated the effects of either the *opportunity* to have an interlock installed^{29,30} or of *actual* interlock installation³¹⁻³⁹ on re-arrest rates for alcohol-impaired driving.

The first study²⁹ of the effects of the *opportunity* to have an interlock installed found that randomization to an interlock program through which 64% of eligible offenders' vehicles had interlocks installed was associated with a 64% relative decrease in re-arrests during the period when interlocks were installed (RR=0.36, 95% CI=0.21, 0.63); following the interlock installation period, re-arrest rates for the intervention and control groups were similar (RR=1.33, 95% CI=0.72, 2.46). The second³⁰ assessed changes in re-arrest rates for a county in which the judge implemented an aggressive mandatory interlock program (in which 62% of eligible offenders' vehicles had interlocks installed) to those for surrounding counties. The authors found a 40% relative decrease in re-arrest rates for first-time offenders ($p=0.04$), and a 22% relative decrease for repeat offenders

($p=0.03$) over a follow-up period that extended for several years beyond the removal of the interlock for some repeat offenders (i.e., those whose DWIs occurred early in the study period).

The nine studies³¹⁻³⁹ that assessed the effects of interlock *installation* consistently found that offenders who had interlocks installed in their cars had recidivism rates (i.e., re-arrests) that were dramatically lower than drivers who did not have interlocks installed (median RR=0.25, interquartile interval [IQI]=0.18-0.46; see [Appendix A](#) for study summaries). Effect estimates were similar for first-time offenders versus repeat offenders. For the period after these interlocks were removed, recidivism rates in the intervention group tended to converge with those for the comparison group (median RR=0.93, IQI=0.67-1.36).

Results from additional studies. The four identified studies^{23,41-43} published subsequent to the Cochrane review found results consistent with those described above. Two studies evaluating the effectiveness of different stages of New Mexico's program found that interlock installation was associated with a 65% lower risk of recidivism among repeat offenders (HR=0.35, $p<0.01$),⁴³ and a 61% lower risk among first-time offenders (HR=0.39, $p<0.01$).²³ For both of these groups, the effects dissipated after the interlocks were removed from the offenders' vehicles (HR=0.91, $p=0.40$, and HR=0.82, $p=0.16$, respectively).

An evaluation⁴² of California's interlock program did not separately estimate interlock effects before and after removal, but found net decreases in recidivism for a period that spanned the time that interlocks were installed and after they were removed. For this extended period, the hazard ratio for all offenders was 0.68 ($p<0.05$) and that for second-time offenders was 0.59 ($p<0.05$). Finally, an evaluation⁴¹ of a Swedish interlock program that included an intensive alcohol treatment component found that the 171 participants had no re-arrests during the follow-up period relative to a recidivism rate of 4.4% per year among nonparticipants. However, these findings do not include people who initially enrolled in the program but were expelled for failing to comply with the alcohol treatment plan.

Conclusions on effects of interlocks on recidivism. These findings suggest that DWI offenders who have ignition interlocks installed in their vehicles are at substantially lower risk for recidivism than those who have had their licenses suspended either after being deemed ineligible for an interlock or deciding not to have one installed. These findings also suggest that the experience of being enrolled in an ignition interlock program by itself does not generally lead to long-term

changes in the propensity to drink and drive that last beyond the period of interlock installation.

These findings have to be considered in light of the possibility that the observed differences in recidivism may actually be due to preexisting differences between the people who installed interlocks and those who did not. Although this potential selection bias is an important factor to consider, two patterns in the results suggest that any such bias is likely to be small relative to the overall effects of interlock installation. First, the results from the single trial²⁹ that randomized people to the interlock condition, and thus protected against this selection bias, were comparable to those from the other studies reviewed. Second, the fact that many of the included studies provide results for both the period during which interlocks were installed and after they were removed allows estimation of the effectiveness of interlocks using the data from the interlock group alone—thus avoiding any biasing effects of differences between people who did and did not have interlocks installed. The interlock groups' dramatic increase in recidivism rates after the interlocks were removed provides further evidence that the results of the comparative studies reflect true effects of participation in interlock programs and are not simply artifacts of group selection.

Effects of Ignition Interlock Installation on Motor Vehicle Crashes

Three of the included studies^{36,41,42} provided data on the effects of participation in interlock programs on motor vehicle crashes. The results of the only study that found a lower overall crash rate among the interlock group (0.0 injury crashes per year relative to 0.6 per year for the control group) were unreliable because of a very low absolute number of crashes studied.⁴¹ A study³⁶ of the Quebec interlock program evaluated its effects on overall crashes and on single-vehicle nighttime crashes (SVNCs; a proxy for alcohol-related crashes) during and after the period in which interlocks were installed. Rates of SVNCs were similar for first-time offenders with interlocks installed relative to those with suspended licenses (HR=1.05, $p=0.85$), and substantially, but nonsignificantly, lower for repeat offenders (HR=0.46, $p=0.14$). In contrast, total crashes were substantially higher for both first-time offenders (HR=3.56, $p<0.01$) and repeat offenders (HR=2.16, $p<0.01$).

The large differences in effect estimates for SVNCs relative to total crashes for both first-time and repeat offenders provide some evidence that interlocks protect against alcohol-related crashes, but that the instal-

lation of interlocks results in an increased overall crash risk relative to that associated with having a suspended license. Results from an evaluation⁴² of the California interlock program support this conclusion. Participants in the California interlock program had an 84% higher chance of being involved in a crash during the study period than the comparison group ($p<0.05$), and repeat offenders had a 130% higher crash risk ($p<0.05$). However, the absolute crash rates for participants were similar to those for the general population of California drivers.

Applicability

One important issue to consider in any systematic review is the potential applicability of the results to situations in which the intervention is likely to be implemented in the future. The studies included in this review primarily evaluated interlock programs that (1) were directed to “hardcore” drinking drivers, either repeat offenders or first-time offenders who had high BACs at arrest (usually >0.15 g/dL), and (2) enrolled a relatively small subset of all DWI offenders. In contrast, to maximize public health impact, interlock programs will need to extend their reach to include a broader cross-section of offenders, and will need to find ways to ensure that a higher proportion of offenders actually have interlocks installed. It is reasonable to assume that interlocks will be effective at reducing recidivism among the broader population of DWI offenders, with expected benefits that are proportional to their baseline rates of alcohol-impaired driving. Nonetheless, further research would be helpful to ensure that interlocks remain effective as their reach is extended.

One important caveat to the expectation that interlocks will be effective at reducing recidivism among the broader offender population is that interlocks require substantial administrative resources to monitor participants. Thus, any major increase in program scope that is not accompanied by an increase in administrative resources may result in decreased effectiveness. Ignition interlock programs typically require offenders to bring their ignition interlock–equipped vehicle in for periodic maintenance and checkup (typically every 30 days). At these checkups, the data stored on the system can be downloaded and examined for signs of failed start attempts, tampering, and circumvention. This type of intensive supervision and monitoring is an essential element of ignition interlock programs and may play an important role in reducing recidivism rates among program participants, both by helping to

ensure compliance with program requirements and by effectively communicating to offenders the need to change their drinking and driving behaviors.

Other Benefits and Harms

The primary goal of this review was to evaluate the effectiveness of ignition interlock programs for reducing alcohol-impaired driving and alcohol-related crashes among people who have been arrested or convicted for alcohol-impaired driving (i.e., the specific deterrence of further alcohol-impaired driving). These programs potentially have either beneficial or harmful effects on the general deterrence of alcohol-impaired driving in the broader population (e.g., by heightening or lessening the perceived severity of the consequences of alcohol-impaired driving). Little is currently known about how ignition interlock programs in general, or their specific features, influence the general deterrence of alcohol-impaired driving.

Participation in ignition interlock programs may be associated with important benefits and harms beyond the effects on alcohol-impaired driving itself. These benefits and harms arise because of two other variables that interlock installation can be expected to affect—driving and alcohol consumption.

Driving

Although it is well known that people with suspended licenses often continue to drive,⁷ interlock participants who can drive legally appear to make more trips and drive greater distances.³² The ability to drive legally can have important benefits to participants and their families with respect to mobility. However, as in all populations, increased exposure to driving is associated with an increased crash risk. The small number of included studies that examined the association between interlock participation and crashes indicated that the interlock groups are involved in more reported crashes than comparison groups with suspended licenses. However, they may not be involved in more crashes than the general driving population. Although more research on the association between interlock installation and subsequent crashes would be valuable, the pattern of results in these studies is consistent with the expected relationships from the current conceptual model. Specifically, it appears that the increased driving exposure of interlock participants results in more total crashes than among those with suspended licenses, but that there is no such increase for alcohol-related crashes.

Alcohol Consumption

Although the reduced recidivism rates shown among interlock program participants is limited to the period during which the interlock is installed, substantial potential exists for synergistic use of interlocks with programs to address offenders' underlying alcohol dependence and abuse problems. By requiring participants to choose between drinking and driving, interlocks provide a consistent behavioral consequence (i.e., the inability to drive) that may discourage drinking on specific occasions in the short term. Alcohol rehabilitation or treatment services during the interlock period may be potentiated by this behavioral contingency. Longer-term alcohol recovery efforts can also be supported by integrating interlocks into a treatment program as a source of objective data on compliance to treatment providers.

Economic Efficiency

Ignition interlock programs have several associated costs (e.g., program administration; leasing, installing, and monitoring the device; auto insurance) and benefits (e.g., increased mobility for the offender, reduced alcohol-impaired driving) that may be important considerations for people making decisions about the structure of interlock programs and for offenders making decisions about participating in them. However, no studies of the costs or economic efficiency of ignition interlock programs that met the requirements for a *Community Guide* review were identified.

Barriers to Intervention Implementation

Few barriers exist to the implementation of ignition interlock programs themselves, and 47 U.S. states have such programs. However, there are important barriers to devising interlock programs so that they enroll a sufficient number of offenders to achieve the greatest public health impact. One important barrier to full uptake of ignition interlocks among eligible offenders relates to the lack of strong incentives for participation in interlock programs. There is almost always an explicit or implicit option to opt out of the interlock program (e.g., by claiming one does not have access to a vehicle), and the common alternative of license suspension may be viewed as less onerous than participation in an interlock program. This view is particularly likely if the offender already has been subjected to a period of license suspension, subsequently has driven illegally, and has found that the risks of being caught and punished are acceptable. Reduction in the time period of pre-interlock license suspension, combined with improved enforcement of and meaningful sanctions for driving while suspended,

may help to make interlocks a more attractive option than license suspension.

Conclusion

Based on the results of the studies identified in the Cochrane review and those of the more recent studies identified in this review, there is strong evidence that interlocks are effective in reducing re-arrest rates while they are installed in offenders' vehicles. The limited available evidence from three studies suggests that alcohol-related crashes decrease while interlocks are installed in vehicles. However, the potential for interlock programs to reduce alcohol-impaired driving and alcohol-related crashes is currently limited by the small proportion of offenders who participate in the programs and the lack of a persistent beneficial effect once the interlock is removed. More widespread and sustained use of interlocks among people arrested for DWI could have a substantial impact on alcohol-related crashes.

Discussion

Although there is often an expectation that all DWI countermeasure programs, including ignition interlock programs, will have a lasting impact on the drinking–driving behavior of offenders, recidivism rates remain at about 25% to 30%. As a temporary form of incapacitation imposed for a fixed period of time, interlock programs are able to reduce recidivism dramatically while the interlock is in place. However, the evidence indicates that it is unrealistic to expect that the device will have persistent effects after removal in the absence of additional program features. Unless interlocks are combined with interventions that address the underlying factors that contribute to recidivism—such as alcohol abuse and the lack of perceived alternatives to driving after drinking—it is likely that many users will continue to drive after drinking once the device is removed.

Future Directions to Maximize the Effectiveness of Interlock Programs

The present review is based on studies of interlock programs in various jurisdictions over the past 2 decades. These programs differ considerably in terms of their structure and operation. In fact, the only truly common feature of these programs is that DWI offenders had an interlock device installed for a given period of time. At one level, this reflects on the robustness of the evidence for the effectiveness of ignition interlocks. At another level, it suggests opportunities to identify and evaluate specific features of programs that show promise for enhancing interlock effectiveness.

This implies that the greatest need for research and actions to improve the effectiveness of interlock pro-

grams in reducing alcohol-impaired driving and alcohol-related crashes relates to the specifics of how programs are implemented and operated. Some key features of interlock programs that could improve their effectiveness include increasing the time period during which the interlock is installed or making the removal contingent on appropriate behaviors, using the interlock in conjunction with alcohol rehabilitation programs, increasing the number of participants, and improving protections against circumvention of the interlocks.

The simplest approach to extending the beneficial impact of an interlock program is to extend the required period of participation in the interlock program. The longer the device is installed, the longer the period of protection from repeat offenses. Unfortunately, research studies to date provide little guidance as to the ideal length of interlock program participation.

An alternative approach is to eliminate fixed periods of interlock installation and implement performance-based criteria for removal based on objective indicators of participants' performance during the period of installation. In essence, before being eligible to have the device removed, participants would have to demonstrate that they no longer need the interlock to prevent driving after drinking. This may require an absence of any positive breath test result on the interlock data recorder for a period of several months before the participant is eligible for release from the program and device removal. To reduce the possibility that offenders might simply park the vehicle for the final few months to avoid having any positive breath test results, evidence of continued driving—either through odometer readings and/or a specified number of breath tests—would have to be included as part of the criteria for removal. Alternatively, or additionally, offenders might be required to submit proof that they successfully had completed a treatment program or were no longer using alcohol and, hence, were no longer at risk of impaired driving.

A key element of efforts to extend the effect of interlock programs may be to combine their use with participation in an alcohol rehabilitation program. This would allow treatment providers to take advantage of the interlock recorder data to provide valuable information about alcohol use to inform treatment planning and modification. One test of this approach found that the interlock provides useful information for treatment specialists in promoting the recovery of DWI offenders³⁸ and identified several important areas for further developments that could enhance impact.

The Swedish interlock program included in this review has a very strong alcohol rehabilitation component and may even be described as an alcohol treatment program that includes an interlock component. The focus of the program is abstinence from alcohol and living a sober lifestyle.⁴¹ The interlock is used to reinforce the goals of the program and to ensure that a relapse does not result in an impaired driving incident. This type of approach requires substantial cooperation and communication among interlock service providers and rehabilitation professionals in the interest of the client.

The ultimate consideration in evaluating the effectiveness of interlock programs is their potential to have a meaningful effect at the level of the overall driving population. Even a highly effective intervention targeted toward individuals will not substantially improve public health unless it reaches an adequate number of people. In the case of interlocks, many programs currently have very low participation rates, and their impact on overall public health would undoubtedly be enhanced through substantially increased participation rates. Taking steps to increase the number of offenders who are eligible for such programs and to increase the proportion of eligible offenders who participate is necessary before overall reductions in alcohol-involved crashes will be realized.

Typically, interlock programs have been targeted to repeat and high-BAC offenders. However, first-time DWI offenders more closely resemble repeat offenders than they do non-offenders, and the results of this review suggest that interlocks are as effective with first-time DWI offenders as they are with repeat offenders. Thus, it would likely be a major boost to overall public safety to require first-time DWI offenders to participate in an interlock program. Making participation in such programs mandatory instead of at the discretion of judges, offenders, or both would also help to maximize interlock use.

However, to be truly effective, even mandatory programs require efforts to help ensure that the goals of full participation are met. These include minimizing the availability of options for not participating, such as a lack of vehicle ownership; requiring installation at the time of arrest rather than waiting until conviction; subsidizing participation for low-income offenders; and ensuring adequate follow-up to determine whether offenders complied with the order to have an interlock installed. Offering interlocks as an alternative to a less attractive sanction also shows promise as a means of increasing participation. For example, a program that offered home confinement as an alternative

to interlock installation raised interlock participation rates to 62%,³⁰ well above that of other programs.

In addition, the effectiveness of ignition interlock programs potentially can be improved by making it more difficult to circumvent the interlock device. The development of improved interlock hardware that is more resistant to circumvention attempts, or detects them more rapidly, may provide incremental benefits over existing hardware. Driver identification systems also show promise as a means to ensure the driver actually provides the breath sample.

However, greater efforts are required to develop effective means of monitoring the most readily available method of circumvention—driving a non-interlock-equipped car. Monitoring the use of the vehicle through an analysis of the number of vehicle starts recorded on the interlock record or the mileage on the vehicle odometer is currently one of the only means of detecting suspected driving of other vehicles and appropriate use of that information is highly dependent on the effectiveness of the interlock monitoring agency. As the number of offenders using interlocks increases, the incidence of driving vehicles not equipped with interlocks will likely become more prominent, and novel means of deterrence and detection will be required.

Perhaps the greatest need at present is for a uniform set of guidelines or standards for ignition interlock programs. Over the years, various groups have established technical standards for interlock devices that serve to ensure that the hardware effectively prevents a person who is impaired by alcohol from operating a vehicle in which the interlock is installed. However, interlock programs require more than just the installation of an interlock device in the vehicle of a convicted DWI offender for a fixed period of time. They require rules and regulations pertaining to eligibility or requirements for program participation, length of participation, extent of monitoring and reporting, agency responsible for monitoring, oversight of interlock providers, and consequences of repeated high-BAC readings or noncompliance with program requirements.

All these factors may play a role in determining the overall success of the program. Aggregating these features into a set of standards or “guidelines for best practices” based on existing research findings would facilitate harmonization and enhance the overall success of interlock programs. An initial set of such guidelines for best practice has been prepared for Canadian interlock programs.⁴⁴

Finally, it is important to establish and maintain a focus on the primary goals for an ignition interlock program. First and foremost, these goals must acknowledge the role of the interlock as an instrument of

incapacitation, a means to prevent a convicted DWI offender from operating a vehicle while under the influence of alcohol. Building a comprehensive rehabilitation program for DWI offenders that incorporates interlocks is a worthy endeavor and one that has tremendous potential for a substantial overall impact on alcohol-impaired driving.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the CDC.

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Appendix A. Evidence table of study details, program details, and results for studies included in this review

Study (Study period) Study design Evaluation setting	Study details	Interlock program details		Results RR or HR for interlock group (95% CI or p-value) Other results	Follow-up period (maximum)
		Administrator Eligibility requirements Installation period Participation rate			
Studies evaluating effects of interlock programs					
Beck (1999) ²⁹ (Not specified) RCT Maryland	Intervention n=698 Comparison n=689 Comparison group consisted of eligible drivers randomized to customary terms and restrictions for multiple offenders	DMV Repeat offenders who had petitioned for and were approved for relicensing (based on treatment compliance and evidence of "recovery") 12 months 64% of offenders randomized to interlock condition		Alcohol traffic violations during interlock period Repeat offenders: RR=0.36 (0.21, 0.63) Re-arrest in year following interlock period Repeat offenders: RR=1.33 (0.72, 2.46)	24 months
Voas (2002) ³⁰ (1/1987-10/1999) Prospective cohort with concurrent comparison group Hancock County, Indiana	First-time offenders: n=21,325 Repeat: n=9356 Comparison group drawn from 6 other suburban counties surrounding Indianapolis	Courts Mandatory (for offenders with vehicles; threat of house arrest for noncompliance) Not specified 62% of offenders		Recidivism following adoption of mandatory interlock policy (adjusted for county, time, age, and gender main effects): First-time offenders: HR=0.60 (p=0.04) ^a Repeat offenders: HR=0.78 (p=0.03) ^a	28 months (first-time offenders) 94 months (Repeat offenders)
Studies evaluating effects of interlock installation (included in Cochrane review)					
EMT Group (1990) ³¹ (3/1987-1/1990) Prospective cohort with concurrent comparison group California	Intervention First-time offenders: n=283 Repeat: n=293 Comparison First-time offenders: n=270 Repeat: n=235 Comparison group matched on six criteria (conviction date, gender, race, age, prior DUIs, BAC level at arrest)	Courts Court discretion; participation mandatory ~50% of sentences were for 36-month periods 775 people sentenced to use interlocks during study period (25% did not install them)		Reconviction during interlock period First-time offenders: RR=0.80 (0.42, 1.53) Repeat offenders: RR=0.53 (0.19, 1.48) Noncompliers with interlock sentences were disproportionately younger. Compliance levels were higher in San Diego, where personal appearances to prove compliance were often required	30 months

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Appendix A. Evidence table of study details, program details, and results for studies included in this review (continued)

Study (Study period) Study design Evaluation setting	Study details	Interlock program details		Results RR or HR for interlock group (95% CI or p-value) Other results	Follow-up period (maximum)
		Administrator Eligibility requirements Installation period Participation rate			
Morse (1992) ³² (7/1987-12/1990) Prospective cohort with concurrent comparison group Hamilton County, Ohio	Intervention n=273 Comparison n=273 Comparison group matched on (1) problem drinker classification; (2) number of DUI arrests; and (3) number of non- DUI alcohol/drug arrests	DMV Court discretion for offenders with (1) BAC>0.20, (2) BAC test refused, or (3) repeat offenders; participation optional 12-30 months 40.5% of eligible offenders		Re-arrest during interlock period All participants: RR=0.33 (0.15, 0.73) People who opted for interlock installation drove more miles than those who did not (e.g., 42% vs 30% drove more than 200 miles/week)	30 months
Jones (1993) ³³ (1 year; 1988-1989) Prospective cohort with concurrent comparison group Oregon	Intervention n=648 Comparison n=1541 Comparison group consisted of drivers in comparison counties who reinstated their licenses	DMV Optional for offenders who have completed 1-3 years of "hard" license suspension (with no additional suspensions during that period) 6 months (in lieu of 6 months' additional license suspension) 18% of eligible offenders		Re-arrest during interlock period Repeat offenders: RR=0.60 (0.35, 1.04) Re-arrest following interlock period Repeat offenders: RR=0.94 (0.73, 1.20) Judges tended to select more serious, habitual offenders for interlock program; offenders who accepted interlocks were more likely to be white, have higher incomes, and have multiple prior DUIs	M~21 months (6 with interlocks installed)
Popkin (1993) ³⁴ (1/1986-3/1992) Prospective cohort with concurrent comparison group North Carolina	Intervention n=407 Comparison n=916 Comparison group consisted of drivers who were granted a conditional license that did not require interlock installation	DMV Optional for offenders who have completed 2 years of "hard" license suspension 24 months (in lieu of 24 months' additional license suspension) 1.8% of eligible offenders		Re-arrest during interlock period Repeat offenders: RR=0.38 (0.20, 0.71) Re-arrest following interlock period Repeat offenders: RR=1.07 (0.53, 2.18)	24 months
Raub (2003) ³⁵ (7/1991-6/2000) Before/after study Illinois	Intervention n=1560 Comparison n=1384 Comparison group consisted of drivers who received restricted driving permits (RDPs) in the 3 years prior to the interlock program (i.e., 7/91-6/94)	DMV Mandatory for offenders who applied for RDPs following a minimum 180- day suspension period 12 months ~14% of eligible drivers		Re-arrest during interlock period Repeat offenders: RR=0.19 (0.12, 0.30) Re-arrest in 2 years following interlock period Repeat offenders: RR=0.52 (0.41, 0.65) ^b Drivers in interlock group were older than those in comparison group (mean age of 38.7 vs 37.5 years, p>0.05)	36 months
Vezina (2002) ³⁶ (12/1997-1/2001) Prospective cohort with concurrent comparison group Quebec	Intervention First-time offenders: n=8846 Repeat: n=1050 Comparison First-time offenders: n=25,559 Repeat: n=7108 Comparison group consisted of drivers who did not participate in the interlock program	DMV Optional 9 months (first-time offenders) or 18 months (repeat offenders) 26% of first-time offenders; 13% of repeat offenders		Re-arrest during interlock period First-time offenders: RR=0.20 (0.14, 0.29) Repeat offenders: RR=0.34 (0.22, 0.53) Re-arrest following interlock period First-time offenders: RR=1.37 (1.21, 1.56) Repeat offenders: RR=1.93 (1.02, 3.66) Single-vehicle nighttime crashes during interlock period	36 months

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Appendix A. (continued)

Study (Study period) Study design Evaluation setting	Study details	Interlock program details		Results RR or HR for interlock group (95% CI or <i>p</i> -value) Other results	Follow-up period (maximum)
		Administrator Eligibility requirements Installation period Participation rate			
				First-time offenders: RR=1.05 (<i>p</i> =0.85) Repeat offenders: RR=0.46 (<i>p</i> =0.14) Total crashes during interlock period First-time offenders: RR=3.56 (<i>p</i> <0.0001) Repeat offenders: RR=2.16 (<i>p</i> <0.0001)	
Tippetts (1998) ³⁷ (1/1990-3/1996) Retrospective cohort with concurrent comparison group West Virginia	Intervention First-time offenders: <i>n</i> =137 Repeat: <i>n</i> =10,198 Comparison First-time offenders: <i>n</i> =591 Repeat: <i>n</i> =20,062 Comparison group consisted of drivers who did not participate in the interlock program	DMV Optional (requires enrollment in a treatment program, and no recent history of driving while suspended) 5 months (first-time offenders); 18 months (second-time offenders) 1.9% of offenders	Re-arrest during interlock period First-time offenders: RR=0.23 (0.01, 3.75) Second-time offenders: RR=0.25 (0.14, 0.43) Re-arrest following interlock period First-time offenders: RR=0.70 (0.32, 1.53) Second-time offenders: RR=2.06 (1.63, 2.60)	30 months	
Voas (1999) ³⁸ (7/1987-9/1996) Prospective cohort with concurrent comparison group Alberta	Intervention First-time offenders: <i>n</i> =1982 Repeat: <i>n</i> =781 Comparison First-time offenders: <i>n</i> =17,587 Repeat: <i>n</i> =10,840 Comparison group consisted of eligible drivers who did not participate in the interlock program	Quasi-judicial board, with licensing authority Mandatory (6% of participants) or optional (94% of participants) for drivers with no arrests during suspension period 6 months (first-time offenders); 24 months (second-time offenders) 8.9% of eligible offenders	Re-arrest during interlock period First-time offenders: RR=0.05 (0.01, 0.18) Second-time offenders: RR=0.11 (0.05, 0.23) Re-arrest following interlock period First-time offenders: RR=0.91 (0.59, 1.39) Second-time offenders: RR=0.96 (0.69, 1.32)	24 months post- interlock	
Marine (2000, 2001) ^{39,40} (9/1996 to 10/2000) Prospective cohort with concurrent comparison group Colorado	Intervention <i>n</i> =501 Comparison <i>n</i> =584 Comparison group consisted of random sample of non-applicants for the interlock program	DMV Optional for repeat offenders Interlock period was double the period of full license suspension <1% of offenders	Re-arrest during interlock period Repeat offenders: HR=0.16 (<i>p</i> =0.0001) ^a Re-arrest following interlock period Repeat offenders: HR=0.58 (<i>p</i> =0.07) ^a Interlock participants were older and had higher incomes.	48 months	
Studies evaluating effectiveness of interlock installation (published after Cochrane review)					
Bjerre (2005) ⁴¹ (1999-8/2004) Prospective cohort with concurrent comparison group Sweden (3 counties)	Intervention <i>n</i> =171 Comparison <i>n</i> =865 Comparison group consisted of matched drivers in comparison counties	Not specified Optional; alcohol treatment required 2 years 11% of eligible offenders	Re-arrest rates (total number of arrests) during interlock period Interlock group: 0.0%/year (0) Comparison group: 4.4%/year (57) Re-arrest rates (total arrests) following interlock period Interlock group: 1.8%/year (3) Comparison group: 4.0%/year (9) Injury crash rates (crashes) during interlock period Interlock group: 0.0%/year (0) Comparison group: 0.6%/year (9) Injury crash rates (crashes) following interlock period Interlock group: 0.9%/year (2) Comparison group: 0.6%/year (2)	>60 months	

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Appendix A. Evidence table of study details, program details, and results for studies included in this review (*continued*)

Study (Study period) Study design Evaluation setting	Study details	Interlock program details		Results RR or HR for interlock group (95% CI or p-value) Other results	Follow-up period (maximum)		
		Administrator	Eligibility requirements			Installation period	Participation rate
DeYoung (2005, 2004) ^{21,42} (1/2000-9/2003) Prospective cohort with concurrent comparison group California	Intervention n=4219 Comparison n=865 Comparison group consisted of matched drivers without interlocks	Courts or DMV	Combination of optional and mandatory	Variable	Not specified	Re-arrest during study period (during- and post-interlock installation) All participants: HR=0.68 (p<0.05) Repeat offenders: HR=0.59 (p<0.05) Crashes during study period All participants: HR=1.84 (p<0.05) Repeat offenders: HR=2.30 (p<0.05) Crash rates for interlock drivers were comparable to those for other California drivers	45 months
Roth (2006) ⁴³ (6/1999-12/2004) Prospective cohort with concurrent comparison group New Mexico	Intervention n=437 Comparison n=12,554 Comparison group consisted of random sample of drivers without interlocks	Courts	Optional (but with a conflicting mandatory license-suspension law)	Not specified	Not specified	Re-arrest during interlock period Repeat offenders: HR=0.35 (p<0.01) Re-arrest following interlock period Repeat offenders: HR=0.91 (p=0.40)	66 months
Roth (2007) ²³ (1/2003-12/2005) Prospective cohort with concurrent comparison group New Mexico	Intervention n=1461 Comparison n=17,562 Comparison group consisted of all first-time offenders without interlocks	Courts	Mandatory for offenders with high BAC (≥0.16 g/dL) or in injury crashes	Mean installation period=197 days	8.8% of offenders with BAC ≥0.16 g/dL	Re-arrest during interlock period First-time offenders: HR=0.39 (p<0.01) Re-arrest following interlock period First-time offenders: HR=0.82 (p=0.16) Re-arrest during study period (during- and post-interlock installation) First-time offenders: HR=0.61 (p=0.61) Interlock group tended to be older (35.7 vs 31.7 years), with more men and high-BAC offenders	36 months

^aResults differ from those in Cochrane review (HRs reported, rather than RRs).

^bResults differ from those in Cochrane review (based on longer follow-up time).

BAC, blood alcohol content; DMV, Department of Motor Vehicles; DUI, driving under the influence; HR, hazard ratio; RDP, restricted driving permit; RR, risk ratio