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Determining a dosage threshold of drink-driving enforcement operations: A systematic review

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Abstract

Issues.—Policy enforcement is crucial to achieve impacts on alcohol-related harm. It is not clear what level of enforcement intensity or "dosage" is necessary for addressing drink driving and related harms. Given competing enforcement demands and agencies' resource constraints, understanding how much enforcement is sufficient to deter drink driving is critical.

Approach.—This systematic literature review followed PRISMA guidelines to examine research about dosage effects of enforcement and related visibility on drink-driving outcomes, including motor vehicle crashes and fatalities. Risk of bias was assessed using the Cochrane Collaboration Effective Practice and Organization of Care (EPOC) tool and the JBI checklist.

Key Findings.—The 21 studies that met the inclusion criteria for this review differed in measures of enforcement dosage and outcomes, making it difficult to synthesize results across studies and draw conclusions about a threshold or optimal level of enforcement. Although most included studies found that sustained enforcement was associated with reductions in drink driving or related harms, only two studies tested an optimal dosage. Due to study design limitations, a substantial percentage of these studies must be considered with caution.

Implications.—Additional research with rigorous study designs with appropriate controls is needed to determine an optimal high visibility enforcement dosage level to help law enforcement agencies make realistic decisions about allocating enforcement resources to address drink driving.

Conclusion.—Consistent evidence about a drink-driving enforcement dosage threshold is lacking, partly due to an insufficient number of well-designed studies. Addressing challenges of conducting rigorous studies in community settings is crucial.

Introduction

Reducing alcohol-impaired driving and related consequences, including motor vehicle crashes, injuries, and fatalities, continues to be a public health priority. It is estimated that

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about 29 people die in an alcohol-impaired driving crash in the U.S. each day. [1] The trend in alcohol-related motor vehicle fatalities has levelled off since 2010, with about 10,000 deaths occurring each year, representing about 30% of all traffic deaths. [2] The majority of alcohol-related traffic fatalities occur among young drivers. For example, in 2017, 68% of drivers in alcohol-related motor vehicle fatalities in the U.S. were 16–34 years old. [1] Concern about impaired driving has led to increased attention to developing effective interventions and the best ways to implement them.

A principal criterion for the implementation of policies is in their enforcement. [3, 4] A systematic review of population-level interventions to reduce alcohol-related harm found "…more consistent support for the effectiveness of interventions targeting alcohol consumption or harm if they involve regulatory or statutory enforcement." [5] Despite the substantial societal costs related to alcohol use in the U.S., resources are limited for enforcing alcohol control policies at the state and local levels. Enforcement agencies often have other priorities that detract from enforcement activities to address alcohol problems such as drink driving.

The deterrent effect of drink-driving enforcement is enhanced when combined with publicity that makes enforcement highly visible. For example, studies have shown that sobriety checkpoints in the U.S. are associated with significant reductions in drink driving crashes, [6–8] especially when coupled with high visibility. [9] Sustained enforcement is a common goal in alcohol policy implementation. What is not clear is the amount or frequency of enforcement necessary to lead to intended outcomes. How much is enough - and how much is too much, wasting time and money and possibly creating a backlash from law enforcement agencies and the public?

Increasing public awareness of policy enforcement through well-publicised enforcement operations is intended to deter violations and not necessarily increase citations or arrests. In fact, the goal of high-visibility enforcement is to create a credible threat of apprehension and punishment that deters or prevents people from violating the law. Deterrence efforts may be specific or general, depending on whether they focus on individuals or the public at large. Laws dealing with drink driving and the enforcement of these laws serve as both general and specific deterrents to drink driving. [10] High visibility enforcement works as a general deterrent, communicating the likelihood of enforcement and arrest to the public, thereby deterring drink driving. Enforcement visibility has been described as "key" to the relationship between enforcement and reductions in drink driving crashes. [11] Within the current debates in the U.S. about reallocating resources away from arrests, a focus on deterrence becomes even more relevant. We wanted to explore what research has been conducted on the necessary or minimum dosage of high visibility enforcement.

The purpose of this systematic literature review is to examine what is known about the intensity or "dosage" of enforcement of laws and visibility of enforcement associated with subsequent reductions in drink driving and related crashes. Laws include those that restrict (1) driving with a blood alcohol concentration (BAC) above a specific limit in milligrams (mg) of alcohol per 100 millilitres (ml) of blood ("per se" laws), (2) impaired driving, (3)

driving with an open container of alcohol, (4) sales to intoxicated persons (SIP); and laws allowing the imposition of immediate roadside penalties.

Methods

Search Strategy

The review was conducted according to the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA) guidelines. [12] Eleven electronic health, safety, and social sciences databases and registers were searched in February and March 2021 to identify studies published in English from 1980 – 2021 on "dosage" effects of alcohol policy enforcement on drink driving and related harms. No limitations on geographical settings or type of study were applied. The primary author (SO) used a broad search strategy that included a combination of appropriate keywords, subject headings, and free-text terms adapted for each database. Search terms included alcohol and driving laws, enforcement level/intensity, and visible enforcement. A complete list of sources, search terms, and number of search results for each source is summarised in Supporting Information, Table S1: Search Strategy. Finally, the reference lists of retrieved articles were searched to locate additional research relevant to this review. Both peer-reviewed and grey literature were included to identify all studies pertinent to the research question in the current review. [13] Data were compiled from systematic searches of electronic sources and through searching for additional relevant literature from references of retrieved articles.

Eligibility Criteria

Studies were eligible to be included in this review if they examined the association between the frequency and/or amount of alcohol policy enforcement and/or publicity about the enforcement, and reductions in drink driving, alcohol-related motor vehicle crashes, or fatal or injury alcohol-related motor vehicle crashes. As stated above, relevant alcohol policies include those that restrict (1) driving with a blood alcohol concentration (BAC) above a specific limit in milligrams (mg) of alcohol per 100 millilitres (ml) of blood ("per se" laws), (2) impaired driving, (3) driving with an open container of alcohol, (4) sales to intoxicated persons (SIP); and laws that allow the imposition of immediate roadside penalties. Enforcement includes sobriety checkpoints, drink driving patrols, random or selective breath testing, drink driving arrests or citations, compliance checks for serving intoxicated patrons at retail alcohol establishments, or undercover operations to observe alcohol serving behaviour in retail alcohol establishments.

Studies were excluded if they examined regulating the physical availability of alcohol (for example, zoning limits or limiting hours and days of sale) or price (for example, tax initiatives). In addition, studies that included multi-component interventions were excluded if they did not identify the specific contribution, or lack of contribution, of enforcement dosage to study outcomes. Finally, studies were excluded if they did not measure actual enforcement levels (as opposed to the perception of enforcement only) and if they failed to include drink driving-related outcomes.

Data screening and extraction

Study selection—The primary author (SO) conducted initial full-text data screening, followed by an independent screening check by a second reviewer (MP). The check revealed high consistency between the reviewers; the few disagreements between the screenings were resolved through discussion and consensus.

Data Extraction—A spreadsheet was created to compile and synthesize essential information from each included article, beginning with a citation identifying the author(s), title, journal, and publication year. Other categories included the study design, location, and measures used. Finally, the study results and/or conclusions and other comments that helped elucidate key findings were noted. The data extraction results for included studies are presented here as a narrative and summarised in a structured table (see Supporting Information, Table S2: Evidence Table). Results of statistical tests are cited in the table if study authors reported them.

Risk of Bias Assessment—The authors used quality assessment tools relevant to the various types of studies included in the review to assess risk of bias. We used the Cochrane Collaboration Effective Practice and Organization of Care (EPOC) tool [14] for randomised control, quasi-experimental, and time series study designs, and the JBI (formerly Joanna Bridges Institute) Checklist for Analytical Cross-Sectional Studies. [15] Two reviewers (SO and MP) conducted the assessments, discussed findings, and came to a consensus about the risk of bias judgments for each included study.

Analysis

We use frequency measures (e.g., number of relevant publications) to describe search results, study designs, populations, dosage measures and outcome measures of included studies. We then provide a narrative synthesis of findings by type of enforcement or visibility dosage measures studied. Based on the studies that met inclusion criteria, we identified the following categories of enforcement operations used as dosage: drink driving arrests, sobriety checkpoints, random breath tests (RBT), alcohol checks, enforcement of sales to intoxicated patrons (SIP), combined strategies, and publicity/visibility. A summary of the findings of the included studies is available in Supporting Information, Table S2: Evidence Table.

Results

Study Selection

The search identified a total of 377 publications, 41 of which were found to be duplicates. After title and abstract screening of the remaining 336, 256 publications were not relevant to the study and were excluded (see Figure 1. PRISMA 2020 flow diagram for exclusion criteria). All but one of the remaining 80 references were retrieved as full-text articles and screened, and sixteen articles were selected for inclusion. In addition, hand searching by checking the reference lists of screened articles identified five additional articles. The list of included publications can be found in Supporting Information, Table 2: Evidence Table.

Characteristics of included studies

A total of 21 studies met the criteria for inclusion in this review. [16–36] Table 1 summarises the characteristics of the included studies. The majority of studies were conducted in the United States, [16–18, 20–25, 28, 29, 31–36] with the remainder in Australia, [19, 30] Canada, [26] and Europe. [27] The most common study design was time series, [19, 22, 24–26, 30, 33, 36] followed by cross-sectional, [18, 21, 27, 29, 31, 32] non-randomised control, [16, 23, 28, 34, 35] randomised control (community) trial, [20] and a modified cross-over uncontrolled before and after study. [17] Study populations included drivers, [17, 19, 20, 22, 24–31, 33, 34, 36] servers at bars and restaurants, [16, 23, 35] law enforcement agencies, [18, 21, 32] and university students. [17]

Studies varied as to the kinds of alcohol policies that were enforced, including laws prohibiting: driving with a BAC above a specific limit in milligrams (mg) of alcohol per 100 millilitres (ml) of blood ("per se" laws), impaired driving, driving with an open container of alcohol, and sales to intoxicated persons (SIP). All studies included drink driving outcome measures. Most studies evaluated enforcement operations that focused on the alcohol-impaired driver, such as sobriety checkpoints, RBT, dedicated drink driving patrols, and/or the number of traffic stops per population. In four studies, interventions focused on alcohol servers, such as bar assessments and undercover operations to enforce sales to intoxicated patrons (SIP) laws in licensed alcohol establishments. Several studies used a combination of interventions, and while a few reported effects of each one separately on drink driving outcomes, most reported effects of the overall enforcement effort.

Risk of bias of included studies

Assessments of the risk of bias of included studies are included in Supporting Information 3, Fig. 3.1: Randomised and nonrandomised studies, Fig. 3.2: Time series studies, and Fig. 3.3: Cross-sectional studies. Most of the studies were found to have study design limitations such as lack of appropriate control conditions, resulting in some concerns about the risk of bias.

Types of policy enforcement activities studied

Eleven studies included drink driving enforcement activities only, such as random breath tests (RBTs), sobriety checkpoints, saturation patrols, drink driving arrests, or a combination of these. [19, 21, 22, 26, 27, 29–33, 36] An additional seven studies examined the effect of drink driving enforcement coordinated with publicity activities to increase the visibility of the enforcement. [17, 18, 20, 24, 25, 28, 34] One of these was an evaluation of high-visibility drink-driving enforcement demonstration projects in seven U.S. States. [25] Three studies focused solely on enforcement of sales to intoxicated persons (SIP) and related visibility to prevent drink driving. [16, 23, 35]

All but two studies [16, 32] acknowledge the importance of highly visible enforcement or public awareness campaigns about enforcement to deter drink driving. Fourteen included interventions with specific visibility or publicity activities; however, visibility was defined or measured in various ways across studies. Some referred to a certain type of enforcement operation (e.g., checkpoint) as highly visible by itself, [19, 21, 27, 30, 31] while others

described publicity and other media efforts designed to bring attention to enforcement activities. [17, 18, 20, 24–26, 28, 34, 35]

Outcomes studied

Drink driving-related outcomes of interest varied among the studies, with some studies using more than one outcome (n=5). Studies that focused on alcohol-related traffic crashes (ARTC) as the primary outcome of interest (n = 13) used various measures, including single-vehicle night-time crashes (SVNC), [20, 23, 24, 26, 34] number of crashes in which at least one victim was injured and required medical treatment, or in which there was more than $1,000 (USD) of property damage, [33] crash rate calculated as total DUI-related crashes among licensed drivers (multiplied by 1,000), [29] alcohol-related fatalities, [22, 25, 36] rate of crashes associated with alcohol-positive driving, [21] and crash rates involving at least one driver with a blood alcohol concentration (BAC) of 0.05 g/ml or greater. [19, 30]

Some studies used self-reported drinking and driving [17, 18, 27, 32] or driver BAC [16, 25, 28, 31] as an outcome. Three studies included as an outcome whether alcohol establishments were named in "Place of Last Drink" (POLD) surveys by people arrested for drink driving. [16, 23, 35] Of these studies, two also measured refusal of sales to intoxicated persons, [16, 35], while the third included police calls for service to bars as an outcome. [23] Less common outcomes included adjudicative outcomes of drink driving arrests [24] and ARTC related costs. [19] It should be noted that some of the studies included outcomes not reported in this review because they were not objective measures of drink-driving or alcohol-related crashes. For example, one study reported binge drinking outcomes, while others included outcome measures of drivers' perceptions of enforcement activity or related publicity or fear of getting caught drink driving.

Analysis of included studies

Study findings indicating a dose-response effect—Based on their findings, the authors of eight studies drew conclusions about a specific dose-response effect of enforcement operations. [19, 21, 22, 27, 30–32, 36] Two of these used the same measures of dosage and outcomes, based on a level of dosage recommended in a 1997 report to the Australian Federal Office of Traffic Safety.[38] Both studies were conducted in Australia with similar populations, and had consistent findings. [19, 30] The authors of both Australian studies concluded that jurisdictions with a ratio of one random breath test per licensed driver per year reported declining trends in alcohol-related traffic crashes and lower rates of self-reported drink driving compared to jurisdictions with ratios of 1:2 or 1:3. These are the only two studies in this review that set out to test an optimal level of enforcement dosage.

A US study used national and state data from 1985–2015 and found that each 1% increase in DUI arrests predicted an 11% decrease in alcohol-related fatal crashes (ARTC), with significant variation in the relationship between arrests and fatal crashes across states. However, the study findings also indicated a change in effect after a certain enforcement level, predicting an increase of 0.013% in ARTCs, possibly due to a saturation effect. [36] The findings among the remaining five studies are inconsistent and external validity

is hampered by study design, sample size, or incomplete data. A summary of all studies' findings can be found in Supporting Information, Table S2: Evidence Table.

Further, to examine whether there was consistency among the studies about a possible dosage threshold, we grouped the included studies and analysed them in two ways: by enforcement type and by how dosage was measured. There is considerable overlap in the reporting below because most studies used multiple enforcement interventions and different ways of measuring the intensity or dosage.

Study findings grouped by enforcement type

1. Sobriety Checkpoints: Results for the ten studies [17, 18, 20, 21, 25, 28, 31–34] that used DUI sobriety checkpoints indicate significant variation in the measurement of dosage for this type of enforcement. For example, some studies used the frequency of checkpoints to measure dosage, others used the number of checkpoints, and some used both frequency and number. Frequency was variously measured daily, weekly, monthly, quarterly, or annually. All but two [28, 32] of the ten studies incorporated other enforcement types in varying doses with checkpoints and did not separately measure the effects of individual intervention types on the outcomes. Although some of these studies found significant effects of increased checkpoints on drink driving related outcomes, none attempted to identify a threshold at which there was an improvement in intervention effects. In addition, the outcomes measured were not comparable across the studies. Moreover, most of the studies were found to have study design limitations, such as a lack of appropriate control conditions.

2. Random breath testing (RBT): Two papers from Australia examined the effect of random breath tests on alcohol-related crashes. [19, 30] The earlier study, in jurisdictions in Queensland and Western Australia, found significant effects associated with increasing the ratio of random breath tests to licensed drivers to 1:1 per year compared to 1:2 or 1:3 per year. However, increasing the ratio of breath tests to drivers in jurisdictions in other Australian states was associated with increases in crashes. This study concluded that accounting for specific state characteristics was necessary, as one explanatory model did not fit adequately for all jurisdictions in Australia. Moreover, the authors left open the question of whether this effect was worth the related cost of increasing enforcement to this level, calling for clarity in the definition of "return on investment" to help decision making about optimal RBT dosage policies. [30] Subsequent research using updated data and the methodology of the previous study calculated a projected saturation rate of breath tests per licensed driver and found an even stronger association between RBTs and alcohol-related crashes over time. In addition, the later study conducted a cost-benefit analysis of increasing the number of RBTs. Based on this, the authors argued in favour of an increase by reporting potential savings relative to increased costs. [19] These are the only studies included in this review that appeared to identify a threshold for drink driving enforcement dosage, although the authors acknowledged potential diminishing effects over time.

3. Saturation Patrols / Drink Driving Patrols: Results for the eight studies [17, 18, 20, 24, 25, 31, 33, 34] using drink driving or saturation patrols show variation in dosage measurement for this type of enforcement intervention. For example, some studies used

the frequency of patrols as a measure of dosage. Frequency was variously measured daily, weekly, monthly, quarterly, or annually. Other studies used the number of patrols, counted either monthly, quarterly, number per 10,000 population or the total number of months conducting patrols. The remaining studies included the number of officers or the number of hours of officer time as measures. Only one of the eight studies measured the effect of saturation patrols and accompanying publicity alone. [24] The other studies incorporated other types of enforcement and publicity in varying doses with patrols and did not separately measure the effects of individual intervention types on the outcomes. As reported above for checkpoints, some of these studies found significant effects of increased enforcement interventions on drink-driving related outcomes. Still, none of them attempted to identify a threshold at which there was an improvement in intervention effects.

4.   Arrest / citations: Six included studies examined the association between arrests or citations and drink driving-related outcomes. [21, 22, 26, 29, 31, 36] Studies measured the number of drink driving (DUI) arrests per 100,000 population, [22, 36] per 10,000 population, [21, 31] and per 1,000 drivers. [26] The remaining study calculated a proactive (unrelated to crashes) drink-driving arrest rate for a two-year period. [29] While this last study found no relationship between the rate of proactive arrests and crashes, the other studies found significant associations between increasing the number of arrests and reductions in drink driving related outcomes. However, there is little consistency among the findings, and the types of outcomes (crashes, fatalities, alcohol positive drivers) varied across the studies.

5.   Sales to Intoxicated Patrons (SIP) Enforcement: Results of four studies [16, 20, 23, 35] focused on preventing sales to intoxicated persons at ABC licensed establishments were mixed. In these studies, enforcement was variously measured as the number of enforcement personnel hours per week, the number of unannounced enforcement personnel visits, undercover SIP enforcement operations to cite overservice, and nonspecific "stepped up enforcement" that included bar assessments by enforcement personnel. Although specific measures of enforcement operations were counted (i.e., number, frequency), no threshold was identified by any of the studies. One study used an aggregate quarterly measure of a variety of enforcement interventions and did not separately measure the effects of SIP interventions on drink driving outcomes. [20]

Studies grouped by dosage measure—Dosage, the independent variable of interest, was also measured in different ways across the included studies, with most studies using more than one measure. Fourteen studies used the number of operations to measure enforcement dosage, [16–21, 23, 25, 26, 28, 30, 31, 33, 36] the most common measure found in this review. Some counted the number of checkpoints, but with varying qualifiers, such as time increment (per year, per quarter, entire project period) or number of personnel (e.g., "low manpower" in one year). Three studies measured dosage as the number of traffic stops per 10,000 population or self-reported alcohol checks in the past three years, while others counted the number of drink-driving patrols (per 10,000 population, or in the past year), open-container enforcement per year, alcohol-licensed premises assessments per year, number of RBTs per licensed driver (monthly per 1000 population and projected saturation

rate), and imposition of immediate roadside penalties. Some of the remaining studies did not limit their counts of operations to a single type of enforcement (e.g., "number of large high-visibility enforcement events," or "number of enforcement operations per quarter").

Six studies measured dosage as the frequency of drink driving checkpoints or patrols. [21, 25, 28, 31, 32, 34] Among the studies, frequency varied to mean enforcement conducted weekly, less than monthly, at least monthly, or per year. Five studies used arrest rates per capita as a measure of dosage, [21, 22, 29, 31, 36] while another used citations per 1,000 drivers. [26] In six studies, the amount of personnel enforcing drink driving laws was a dosage measure. [17, 21, 24, 26, 31, 35] These ranged from the number of officers, the number of officers per 10,000 population, the number of officer hours for patrols, the number of officer hours per week, and simply the presence of a traffic unit. Less common dosage measures were the number of months conducting "high intensity" enforcement, [24] and the number of breath test devices in operation. [34]

Frequency and number of enforcement operations were both used as dosage measures in some studies, but their effects were analysed in combination, preventing the assessment of the effect of either measure separately. None of the types of dosage measure was compared to another type, nor was any type of enforcement or visibility determined to be more effective than the others.

Discussion

Determining the optimal/threshold dosage level for high-visibility enforcement of drink driving laws can help government officials and law enforcement agencies use available resources more efficiently and reduce harms from alcohol-related motor vehicle crashes. This systematic review was conducted to assess the research in this area. At the time of this review, twenty-one studies were identified that examined the association between the dosage of enforcement operations and reductions in drink driving-related outcome measures. Studies that included multi-component interventions were excluded if they did not identify the specific contribution, or lack of contribution, of enforcement dosage to study outcomes

Dosage was variously referred to as frequency, number, and intensity and was measured differently across the studies. While the studies emphasised the need for sustained or increased enforcement to achieve desired outcomes, there was little consistency in study methodology regarding enforcement or visibility dosage measures and little forethought about optimal levels of enforcement or visibility. Thus, study findings were inconsistent regarding a necessary level or threshold of enforcement dosage. This is due, in part, to the differences in existing policies in study communities, types of enforcement interventions used, and the designs and sizes of the studies.

Alcohol policies in different U.S. states and other countries sometimes dictated what types of interventions could be evaluated. For example, in Australia and some countries in Europe, it is permissible to conduct random breath testing (RBT) to check for driving under the influence. However, in the United States and other European countries where most studies took place, it is only permissible to conduct selective breath testing based on

police observation of obvious indicators of impaired driving. Therefore, while studies in Australia may recommend conducting a ratio of one random breath test per licensed driver per year, this would not apply to countries where RBTs are not legal. Similarly, some states in the U.S. do not allow sobriety checkpoints. Therefore, for example, a U.S. study showing significant effects of conducting sobriety checkpoints monthly could only apply to states where sobriety checkpoints are permitted by law.

Two studies discussed a "decaying" effect of enforcement over time, suggesting the need for ongoing enforcement to maintain beneficial effects. One of these found that fewer alcohol-related crashes occurred for up to about a week after checkpoints were conducted, after which the effects appeared to diminish. [33] The other focused on alcohol service to intoxicated persons, showing an increase in refusal rates within three months after the enforcement checks, followed by a decline from the three months to a year after enforcement. The increase in refusals was accompanied by a reduced percentage of people arrested for drink driving who reported bars and restaurants as their place of last drink. [35] Other studies observed "diminishing returns" of increased enforcement based on the cost of maintaining high enforcement levels versus the benefits of doing so, [19] or the eventual unintended association between enforcement saturation and predicted increases in fatal crashes.[36]

Five studies found effects of a higher number of drink-driving arrests, using a variety of outcome measures, including alcohol involvement in crashes, alcohol-involved crash fatalities, and prevalence of night-time drivers who were alcohol positive or alcohol-impaired according to a 2007 U.S. survey. A higher number of arrests was found to be associated with reductions in the drink driving outcome measures, at least temporarily, in each study. While these findings reinforce the hypothesis that higher arrest rates lead to reductions in drink-driving problems, most do not offer a specific minimum dosage level needed to see any effects. There may also be a possible maximum dosage level above which there no improvement in drink-driving related problems. The one study identifying a specific dose-response relationship of arrests to alcohol-related fatal crashes also predicted a possible saturation effect at higher levels of enforcement, followed by an increase in fatal crashes. Moreover, the findings indicated that alcohol consumption rates, population size, and vehicle miles travelled were stronger predictors of fatal alcohol-related crashes than were arrests. [36]

Two studies reported challenges with obtaining accurate levels of enforcement activity. Specifically, the authors noted that some police agencies did not supply data about the number of sobriety checkpoints they conducted, which limited analyses to examine dosage effects of sobriety checkpoints and the applicability of study results to the broader population. [21, 31] Thus, obtaining reliable data from enforcement agencies is one of the challenges for estimating a minimum threshold for enforcement dosage to achieve reductions in drink driving and alcohol-related crashes and fatalities.

Several studies incorporated a combination of enforcement activities with various dosage measures, making it difficult to attribute results to any one type. In addition, visibility of

enforcement was mentioned in nineteen studies but was only included in the interventions of eight studies, with no consistency in findings regarding a necessary dosage amount.

In summary, this systematic literature finds inconclusive evidence about a threshold level of high-visibility enforcement dosage to reduce drink-driving and related problems. Apart from two studies in Australia, little attention has been given to assessing predetermined specific dosage levels on drink driving outcomes. Moreover, no randomised controlled studies have been conducted to address this question. Though challenging and expensive, randomised community trials that test different dosage levels of various high-visibility enforcement strategies can compare possible differences in effectiveness. At a minimum, synthesis of future research findings would be facilitated by standardising measures of dosage and outcomes across studies regardless of study design.

Limitations

The applicability of the results found by studies in this review is primarily limited by the dearth of high-quality study designs. Six studies used cross-sectional designs, which are useful for examining associations between interventions and outcomes and developing hypotheses. However, a cross-sectional study does not provide evidence of causation, nor even temporality in many cases. Eight studies used quasi-experimental designs, which have advantages over cross-sectional designs in that they include comparison groups and can track changes over time, for instance. However, because groups are not randomly assigned to intervention or comparison conditions, these studies are subject to internal threats to validity, including selection bias. This makes it difficult to know whether observed changes are due to actual intervention effects or to differences between the groups before the intervention occurred. This concern is addressed by randomising groups to intervention or comparison conditions, which was employed in only one study in this review.

Conclusion

The findings of this review indicate that regular, sustained enforcement of alcohol policies may reduce drinking to intoxication, drink driving, crashes, and related harm. However, the results reveal limited consistent findings in the research literature about a threshold or recommended enforcement intensity associated with reductions in drink driving and associated problems. Similarly, this review did not identify an optimal dosage for publicising drink driving enforcement operations to raise visibility. While some studies defined "high" and "low" levels of enforcement intensity, all but one of these were mainly based on posthoc comparisons between actual levels of enforcement that were implemented in study communities and are not based on a "standard" that can be used generally. Therefore, the reported levels may not have practical value for communities hoping to replicate a specified number of enforcement operations to reduce alcohol-related problems. Future research should build on these findings by using rigorous study designs and focusing on testing measures of dosage of enforcement and visibility suggested by the results of the studies in this review. Further study is needed to support communities in making realistic decisions about allocating resources for high visibility enforcement to address alcohol overservice, drink driving, and related problems.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

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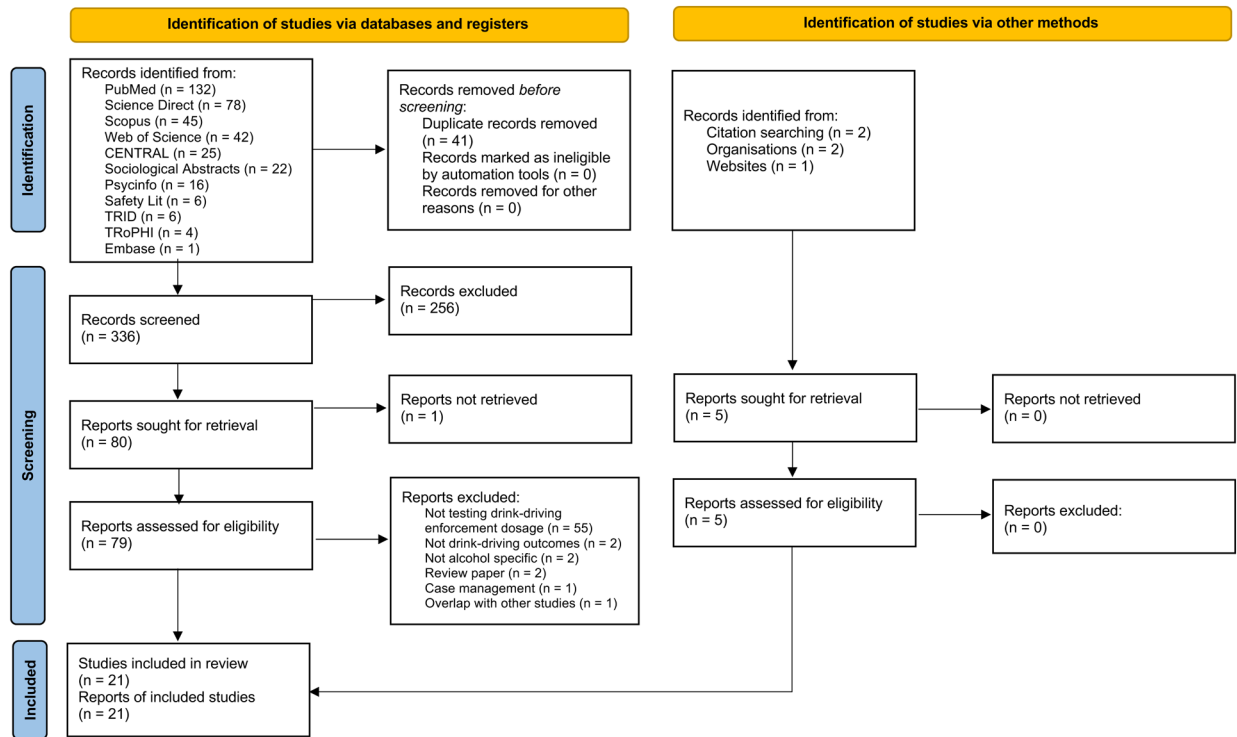
Figure 1.
Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 flow diagram

Table 1.

Characteristics of Included Studies

	Study Characteristics[*]	Number of papers
Design	Time series	8
	Cross-sectional	6
	Non-randomised control	5
	Randomised community control	1
	Modified crossover (before and after)	1
Population	Drivers	15
	Alcohol servers	3
	Law enforcement agencies	4
	Students	1
Country	United States	17
	Australia	2
	Canada	1
	Europe (19 countries)	1
Intervention(s)	Drink-driving checkpoints	10
	Publicity / visibility activities	10
	Drink-driving patrols	8
	Arrests / citations	6
	Sales to Intoxicated persons (SIP) enforcement	4
	Random breath tests	2
	Alcohol checks (self-reported)	1
Dosage measure	Number of operations	13
	Frequency of operations	6
	Amount of enforcement personnel (number, hours)	6
	Arrest / citation rates	6
	Amount of equipment	1
	Duration of "high intensity" intervention (months)	1
Drink- driving related outcome	Alcohol-related traffic crashes	10
	Drinking and driving (self-reported)	5
	Blood alcohol content (BAC)	3
	Mention in "Place of Last Drink" survey (bars, restaurants)	3
	Alcohol-related traffic fatalities	3
	Drink-driving arrests	2
	Refused sales to intoxicated patrons	2
	Alcohol-related traffic crash costs	1
	Alcohol-related traffic injury crashes	1
	Drink-driving arrest adjudicative outcomes	1
	Police calls for service (bars, restaurants)	1

[*] Some studies fit into multiple categories if they used more than one outcome, intervention, or dosage measure.