Can a criminal justice alcohol abstention programme with swift, certain, and modest sanctions (24/7 Sobriety) reduce population mortality? A retrospective observational study

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Summary

Background In the UK and USA, various jurisdictions have launched new approaches for managing alcohol-involved offenders that might have public health implications. These programmes require participants to abstain from alcohol and submit to frequent alcohol testing with swift, certain, and modest sanctions for violations, with the aim to reduce crime and keep alcohol-involved offenders in the community. In this study we examine whether the 24/7 Sobriety programme in South Dakota, USA—the largest such programme to date—is associated with reductions in mortality.

Methods With a differences-in-differences design, we used variation in the timing of 24/7 Sobriety implementation across South Dakota counties between 2005 and 2011 to estimate the association between programme introduction and county-level mortality. We used monthly, county-level, aggregate counts for mortality from January, 2000, to June, 2011. We assessed total deaths, and deaths due to external injuries, circulatory disorders, digestive disorders, and cancer (as a potential placebo).

Findings Between January, 2005, and June, 2011, 16 932 people (about 3% of the adult population) participated in the 24/7 Sobriety programme. The analysis was based on a sample size of 9108 county-month observations (ie, 66 counties × 12 months × 11·5 years). Implementation of 24/7 Sobriety was associated with a 4·2% (95% CI 1·5–6·9) reduction in all-cause adult mortality, with the largest associations among women (8·0%, 95% CI 3·9–11·8) and individuals older than 40 years (4·3%, 95% CI 1·4–7·0). Associations were most evident among circulatory disorders.

Interpretation 24/7 Sobriety might have public health benefits, which could extend beyond individuals directly enrolled in the programme. However, further research, including randomised controlled trials and analyses of individual-level data, is needed to corroborate the finding, reassess the size of these associations, and gain insight into causal mechanisms. Should a negative association be replicated, it might represent a substantial advance in our understanding of how criminal justice interventions could help shape public health.

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Introduction

Alcohol consumption can impose massive harms, with some estimates suggesting that alcohol costs the UK about £20 billion annually.[1] Mortality constitutes one of the most costly consequences of heavy alcohol use and might affect users and non-users through biological mechanisms, dependence, and intoxication.[2] The nature of consumption, especially heavy drinking episodes and past alcohol problems,[3] and the presence of alcohol at the time of injury, play a part in mortality.[4] Women seem to be especially sensitive to adverse outcomes associated with heavy alcohol use.[5]

Alcohol-related consequences are particularly common among alcohol-involved offenders,[6–8] although evidence is lacking for mortality among such populations in the UK and the USA. Programmes aimed at reducing alcohol-related harms have had mixed results,[9,10] in part based on whether they target those drinkers most likely to impose harms and the extent to which they reduce heavy drinking.

In 2003, South Dakota Governor Mike Rounds established a corrections task force focused on reducing the prison population. Because alcohol misuse was a factor for a significant share of prisoners, there was a focus on reducing alcohol consumption. As a result of this task force—and especially the efforts of then Attorney General Larry Long—counties in South Dakota implemented a novel and targeted intervention (the 24/7 Sobriety programme) to reduce alcohol consumption for those individuals whose use threatened public health and safety.

South Dakota's 24/7 Sobriety programme (hereafter, 24/7 Sobriety) requires that alcohol-involved offenders subject to community supervision (eg, pre-trial release, probation) abstain from alcohol. The programme is intensive in that participants must submit to twice-a-day breathalyser tests, typically 12 h apart (eg, 0700–0900 h and 1900–2100 h), or wear continuous alcohol monitoring bracelets. Twice-a-day testing is unlikely to detect all drinking because alcohol passes through the body relatively quickly, but it is likely to identify heavy drinking.

Participants who test positive or skip a test are subject to an immediate, but brief jail term (typically 1 or 2 days for a failed test). 24/7 Sobriety is not ordered in lieu of treatment; judges can order individuals to

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Research in context

Evidence before this study

Key studies in the scientific literature provide evidence on the efficacy of population-level interventions targeting alcohol consumption including alcohol taxes, minimum legal drinking ages, and thresholds for driving under the influence. Criminal justice interventions for alcohol-involved offenders typically focus on reducing alcohol consumption or reducing the criminal behaviour (eg, driving under the influence) among offenders. A meta-analysis of remediation programmes targeting driving under the influence offenders including treatment, education, psychotherapy, counselling, and contact probation finds that these programmes lead to at least a 7–9% reduction in driving under the influence recidivism and alcohol-related crashes. Meta-analyses of ignition interlock devices suggest they reduce rearrests for driving under the influence by about two-thirds, typically only when devices remain on the automobile; however, a recently published study found evidence of longer-term effects of ignition interlock devices on driving under the influence recidivism. Few studies have measured the population-level effects of these criminal-justice interventions—rather than the effects on participants only—and those that do typically focus on criminal justice or traffic safety outcomes. Results of one such study of 24/7 Sobriety—which orders alcohol-involved offenders to frequent alcohol testing with swift, certain, and fair sanctions for a failed or missed test (typically a night or two in jail for a failed test)—showed that after counties implemented the programme there was a statistically and substantively significant reduction in the total number of arrests for repeat drunk driving (12%, p<0·05) and domestic violence (9%, p<0·05) in these counties.

Added value of this study

This study represents the first attempt to assess the association between 24/7 Sobriety and a traditional health outcome: mortality. Analysing county-level data, implementation of 24/7 Sobriety in South Dakota—the largest 24/7 Sobriety effort to date—is associated with a reduction in mortality of 4·2% (95% CI 1·5–6·9; p<0·01). The association is evident among causes strongly and often acutely associated with excessive alcohol use such as circulatory conditions. These results provide additional support for 24/7 Sobriety programmes and suggest a potential approach to help reduce alcohol-involved mortality. The results are larger than anticipated, suggesting that spillover or other factors contributed to the estimates.

Implications of all the available evidence

The results should support policy makers' efforts to promote pilot programmes in their jurisdictions. Experimental evidence of 24/7 Sobriety and analyses using individual-level data are needed, which can provide greater opportunities to refine estimates and mechanisms. We urge researchers and practitioners to explore the possibility of incorporating randomisation into future efforts. Since 24/7 Sobriety programmes attempt to change behaviour primarily with sticks instead of carrots (ie, punishments rather than positive incentives), future iterations should also consider how contingency management and formal treatment could be incorporated.

"complete any evaluation, counselling, treatment, or aftercare as directed by the Court or Court Services Officer".[11] Additionally, those convicted of a repeat drunk driving offence must complete a court-ordered treatment programme before obtaining a restricted driving permit. South Dakota first applied the combination of frequent monitoring with swift and certain sanctions among repeat drunk driving offenders in three pilot counties and eventually to other alcohol-involved offenders statewide.

By contrast with traditional supervision models, 24/7 Sobriety features a high probability of detection and certain, immediate sanctions that might prove more conducive to reducing problem drinking and public health harms. 24/7 Sobriety is consistent with research from neurobiology, psychology, and economics, which suggests that punishment certainty is a stronger deterrent to criminal activity than severity,[12,13] and that individuals value immediate rewards more strongly than delayed rewards,[14] particularly among populations who misuse alcohol.[15] Research suggests that abstinence orders combined with frequent testing and swift and certain sanctions can deter illegal drug use among probationers[16] and physicians.[17] As argued by Strang and

colleagues,[18] "increasing evidence shows that specific, immediate, and brief sentences (eg, overnight) for positive drug tests produce substantial reductions in drug use and offending in individuals who are under criminal justice supervision".

Recent empirical evidence also suggests that this approach might reduce heavy drinking and its consequences. First, between 2005 and 2013, more than 25 000 unique participants in South Dakota accumulated more than 4·5 million days without a detected drinking event. The pass rate on breathalyser tests exceeded 99% with the remaining results split between positive (0·36%) and skipped tests (0·34%).[19,20] This result shows good efficacy in light of the high rates of alcohol use and disorders among criminal justice populations, especially driving under the influence arrestees.[7] About half of the participants did not have a detected violation during participation. Among those with any violations, the most common pattern was a single violation. The extent to which individuals altered their drinking after exiting the programme, however, remains unknown. Second, previous studies have shown South Dakota's 24/7 Sobriety programme to be associated with significant reductions in repeat driving under the influence arrests (12%), domestic

violence arrests (9%), and traffic crashes among young men (4%) at the county level.[19] Additional analyses using a different data source, triple-difference methodology, and a limited set of counties provide additional support for reductions in alcohol-related offending (unpublished data). Both analyses were done at the aggregate county-level (rather than just among participants), and thus capture spillover effects onto non-participants, who may be drinkers seeking to avoid 24/7 Sobriety or non-drinkers affected by drinkers. Third, preliminary evidence from another US state provides additional support that 24/7 Sobriety reduces the probability of future arrests for driving under the influence.[21]

This model has recently been adopted in other US states and a modified version is being piloted by the Greater London Authority, which provides a motivation for this study.[22]

We provide a first look at whether 24/7 Sobriety is associated with a reduction in mortality. Understanding the implications of such programmes is crucial because alcohol use is common among offenders[7,23] and alcohol-involved offenders experience higher than expected mortality.[6,24] Moreover, considering the programme's effect on population—rather than simply participant—mortality is valuable because 24/7 Sobriety might reduce drinking among those drinkers not yet ordered to the programme (ie, deterrent effect) and mortality among those adversely affected by drinkers' behaviours, for example, through injury. Thus, we hypothesised that 24/7 Sobriety would be associated with a reduction in mortality for causes that are sensitive to heavy alcohol use.

Methods

Study design and statistical analysis

The analyses estimate the association between 24/7 Sobriety and mortality using a differences-in-differences approach that compares changes in mortality within counties that implemented 24/7 Sobriety to changes within counties that had not yet. The methodology takes advantage of a nearly 12 year panel of monthly county-level mortality data spanning January, 2000, to June, 2011. Because the associations are estimated based on comparing within-county changes in mortality to within-county changes in programme availability, the approach does not rely solely on the cross-sectional variation that might bias estimates due to uncontrolled heterogeneity across counties. The statistical model is:

$$Y_{it} = \alpha 24/7_{it} + \beta X_{it} + \gamma_i + \delta_t + \varepsilon_{it}$$

where the dependent variable, Y_{it}, represents counts of adult deaths in county i and month t. The time-varying indicator variable, $24/7_{it}$, captures whether 24/7 Sobriety was operational in county i and month t (described below). ε_{it} is a random error term. We expect that the coefficient of

interest, α, will be negative because 24/7 Sobriety should be associated with a reduction in mortality if heavy drinking is curtailed. The model controls for time-varying county characteristics (X_{it}) including the unemployment rate, snowfall, an indicator variable for the Sturgis Motorcycle Festival (ie, Pennington, Meade, and Lawrence counties in August), an indicator for whether college was in session for the four counties with substantial student populations, and a fifth order polynomial of first-time driving under the influence arrests to proxy for prevalence or enforcement. Per capita vehicle miles travelled (for total and external injury deaths only), per capita police officers, per capita on-premises and off-premises alcohol outlets, and demographic characteristics including log of total population, share of males aged 18–40 years, share of males 60 years or older, share of females 60 years or older, and share white are available only annually, but were linearly interpolated to construct monthly measures. County fixed effects control for the unobservable characteristics of each county that remain constant over time (γ_i), whereas time fixed effects (δ_t) for each month (eg, Jan, 2011; Feb, 2011) control for seasonal and temporal shocks common to all counties (eg, statewide policies).

The models are estimated using Poisson regression to account for the count nature of the dependent variables. The Poisson model provides consistent estimates of the conditional mean function across a wider range of data-generating processes than some other count models.[25] To ensure valid statistical inference even under a failure of the Poisson equal mean-variance assumption or with arbitrary forms of within-county autocorrelation in error terms, we report cluster-robust 95% CIs with clustering at the county level.

The independent variable of interest is the indicator variable for whether 24/7 Sobriety is operational in each county—defined as whether the number of county residents participating in 24/7 Sobriety for a given month equals or exceeds a quarter of the number of driving under the influence arrests in the county, in which the latter is defined as the moving average during the previous year to address seasonality. This definition applies well to large and small counties and minimises false positives that arise when counties have a few residents participating before the programme's formal establishment. In a sensitivity analysis, we used alternative threshold definitions of 40% and 10% of driving under the influence arrests rather than 25%. The study was approved by the RAND Institutional Review Board.

Data sources

The Centers for Disease Control and Prevention's National Vital Statistics System (NVSS) contains the cause of death, month and year of death, and county of residence and death for each individual (appendix). For each county-month, counts were constructed for total deaths and deaths due to particular causes. Counts are based on county of residence because exposure to 24/7 Sobriety is

more likely to occur based upon residence. The data were available consistently from Jan, 2000, to June 2011, which allows for pre-programme and post-programme periods.

Outcomes

In view of the relatively small number of deaths monthly for South Dakota's smaller counties, we rely on the broader ICD-10 chapters when creating counts by cause (eg, all external injuries rather than more specific causes such as motor vehicle fatalities or suicide). The trade-off between specificity in diagnoses and precision with respect to timing and location is dictated by our identification strategy described above, which relies on the variation in timing of implementation across counties. The analyses focus on causes that the literature suggests are strongly related to alcohol, are likely to be affected in the short term, and have sufficient prevalence.[2,10] Based on these criteria, we focus primarily on total deaths, digestive deaths, deaths due to external injuries, and deaths due to circulatory conditions. Although certain cancers might be sensitive to alcohol use, cancer-related deaths have been used as a falsification test in other studies because overall cancer deaths are unlikely to respond to such interventions.[10] All analyses were done with Stata version 12.1.

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

16 932 unique individuals—about 3% of South Dakota's adult population—participated in 24/7 Sobriety between Jan, 2005, and June, 2011. 10 812 were subject to a repeat driving under the influence offence, 2703 for first-time driving under the influence, 2198 for assault or domestic violence, and 7054 for other offences. The mean participation length was 122 days (SD 159) for those assigned to twice-daily breathalyser tests and 184 days (SD 188) for those assigned to continuous monitoring devices (offence and duration calculations include those who ended participation after 1 day and those who entered the programme more than once). The mean times for the first failed test for participants with any violations was 61 days (SD 96) for males and 54 days (SD 83) for females.

Descriptive statistics for outcomes and covariates are shown in table 1. The table is based on 9108 county-month observations (ie, 66 counties×12 months×11·5 years), not the number of individuals participating in the programme. Figure 1 shows the timing of implementation across South Dakota's 66 counties using our threshold definition; annual participation totals by year are provided in the appendix. Based on our threshold definition, about one-third of counties had sufficient participation to exceed the threshold by early 2007, another third by early 2008, and almost all of the remaining counties by December 2008. The rapid implementation after mid-2007 was probably affected by the unanimous passage of South Dakota House Bill 1072, which provided funds to counties to adopt the

	Mean (SD)	Minimum	25th percentile	50th percentile	75th percentile	Maximum
Dependent variable						
All deaths	8·66 (13·74)	0	2	5	10	124
Circulatory deaths	3·09 (4·88)	0	1	2	4	49
External injury deaths	0·61 (1·28)	0	0	0	1	16
Digestive deaths	0·36 (0·80)	0	0	0	0	10
Cancer deaths	2·00 (3·62)	0	0	1	2	39
Independent variable						
Share female aged 60 years or older	0·124 (0·037)	0·039	0·098	0·126	0·151	0·209
Share male aged 60 years or older	0·096 (0·028)	0·029	0·077	0·099	0·118	0·162
Log population	8·713 (1·008)	6·914	7·949	8·620	9·212	12·118
Share white	0·852 (0·241)	0·049	0·882	0·962	0·986	0·999
Share young male	0·133 (0·032)	0·076	0·111	0·126	0·151	0·257
Unemployment rate	4·154 (2·120)	1·400	2·800	3·600	4·800	20·000
Police per 10 000 people	13·933 (5·607)	0·000	10·151	14·044	17·462	34·479
Bars per 10 000 people	5·679 (3·971)	0·000	3·023	5·307	7·701	23·328
Package stores per 10 000 people	2·061 (2·120)	0·000	0·000	1·544	3·301	10·828
Log snowfall	0·097 (0·147)	0·000	0·000	0·001	0·161	1·611
Sturgis Motorcycle Festival	0·004 (0·060)	0·000	0·000	0·000	0·000	1·000
College	0·051 (0·219)	0·000	0·000	0·000	0·000	1·000

Unit of observation is the county month. Sample size is 9108 for all variables.

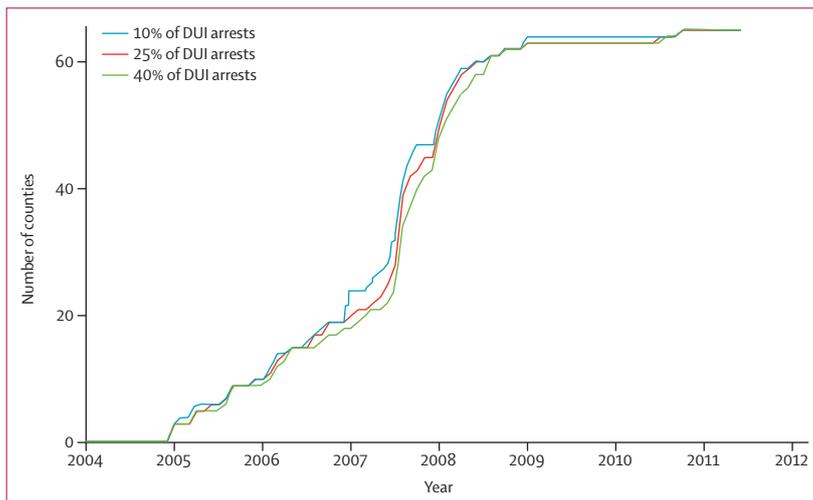*Table 1:* Sample statistics (Jan, 2000, to June, 2011)

Figure 1: 24/7 Sobriety implementation thresholds
DUI=driving under the influence.

programme. The state law also officially expanded the programme beyond repeat driving under the influence offenders by allowing courts and other criminal justice agencies (eg, parole) to order any alcohol-involved offenders, pre-conviction or post-conviction, to participate. Figure 1 also shows the primary implementation measure based on the 25% threshold described earlier, and alternative implementation measures defined using thresholds of 40% and 10%.

Figure 2 shows mortality counts re-centred around each county's programme implementation date and suggests a potential break in mortality. The blue line is the actual count whereas the grey lines are linear fits specific to the pre-implementation and post-implementation periods. Similar figures were generated for external injuries, circulatory conditions, and digestive conditions (appendix).

Results suggest the implementation of 24/7 Sobriety is associated with a reduction of 4·2% (95% CI 1·5–6·9) in all-cause mortality, although the somewhat large CI includes an association as small as 1·5% (table 2). This result is a large point estimate given that it is measured at the county level rather than among participants. The association appears concentrated among women (8·0%, 95% CI 3·9–11·8) and those older than 40 years (4·3%, 1·4–7·0). The result for deaths due to external injuries also suggests a decline, although not significant (10·7%). The point estimate is also imprecise for women (13·0%), but significant for those older than 40 years (12·5%, 95% CI 0·4–23·2). For circulatory conditions, the model produces a statistically significant finding overall (6·8%, 95% CI 1·1–12·1) with similarly sized estimates among women (8·1%, 0·8–14·9) and those older than 40 years (6·9%, 1·3–12·1). The results for mortality due to digestive conditions, including liver conditions, are negative, but never significant.

Sensitivity analyses suggest that these findings are robust for all-cause adult mortality (table 3). When the models include county-specific linear trends, the coefficients remain largely unchanged. The results are also robust to the exclusion of small counties (ie, defined as counties with populations less than 5000) and the exclusion of counties with more than 50% of land defined as tribal reservations. The fact that these results are qualitatively similar suggests that random variability among small counties and potential changes in reporting among reservation counties do not explain the main findings. Alternative definitions for the implementation thresholds of 10% and 40% also yield qualitatively similar findings. Robustness results for deaths due to external injuries and circulatory conditions are also similar to the main results albeit with some loss of precision (appendix).

To address the concern that the findings reflect a decline in mortality unrelated to 24/7 Sobriety, the model was estimated for cancer-related deaths (table 2). The estimates were essentially zero overall and for those
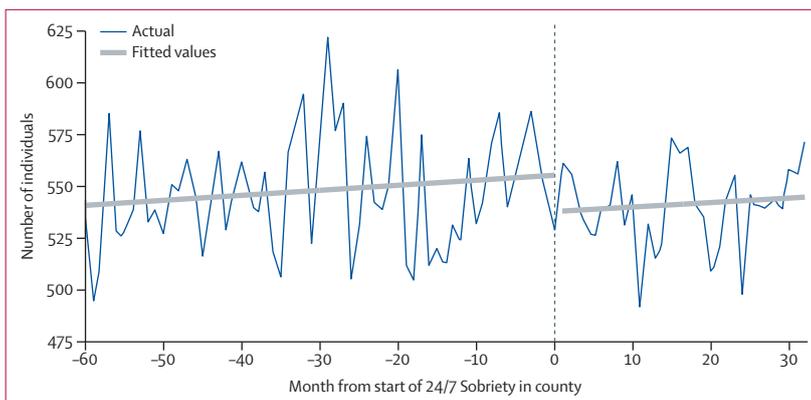

Figure 2: Mortality (all conditions)
A programme is considered active when the number of participants in a given month equals or exceeds a quarter of those arrested for driving under the influence. Excludes counties with less than 32 months of post-treatment data.

	All deaths	External injury	Circulatory	Digestive	Cancer
All	–0·043* (–0·072 to –0·015)	–0·113‡ (–0·236 to 0·009)	–0·070† (–0·129 to –0·011)	–0·078 (–0·233 to 0·076)	–0·004 (–0·061 to 0·052)
Male	–0·004 (–0·041 to 0·032)	–0·098 (–0·241 to 0·045)	–0·056 (–0·127 to 0·015)	–0·095 (–0·273 to 0·084)	0·053 (–0·040 to 0·145)
Female	–0·083* (–0·125 to –0·040)	–0·14 (–0·325 to 0·045)	–0·085† (–0·161 to –0·008)	–0·06 (–0·290 to 0·170)	–0·067‡ (–0·145 to 0·011)
Age >40 years	–0·044* (–0·073 to –0·014)	–0·134† (–0·265 to –0·004)	–0·071† (–0·129 to –0·013)	–0·076 (–0·233 to 0·080)	–0·006 (–0·063 to 0·051)

Poisson coefficients shown but converted for text. Outcome is the count of cause-specific deaths per county and month; sample size is 9108. CIs based upon SEs clustered at the county level shown in parentheses. Models include unemployment rate, log snowfall, an indicator variable for the Sturgis Motorcycle Festival, an indicator for whether college was in session in the four counties with substantial student populations, a fifth order polynomial of first-time driving under the influence arrests to proxy for enforcement, per capita vehicle miles travelled (for external injury and total deaths only), per capita police officers, per capita on-premises and off-premises alcohol outlets, demographic characteristics including log of total population, share of males aged 18–40 years, share of males 60 years or older, share of females 60 years or older, share white, county-fixed effects, and year–month fixed effects. *p<0·01. †p<0·05. ‡p<0·10.

Table 2: Main results (Jan, 2000, to June, 2011)

older than 40 years; there were also no significant associations for men and women, although the point estimates were larger.

Discussion

Our retrospective observational study finds an association between a criminal justice alcohol abstention programme (24/7 Sobriety) and population mortality. The main results suggest a larger-than-anticipated 4·2% reduction in adult mortality with a wide CI.

Caution and further research are needed because the association seems rather large relative to programme participation, which totalled only 3% of the adult population by 2011. Concerns also exist about the degree of concentration among women and those older than 40 years, given that women (25%) and those older than 40 years (25%) represent a smaller share of participants. Reductions appear most evident among conditions sensitive to alcohol such as circulatory conditions. The large estimates also parallel previous findings with

	With county time trends	Large counties	Non-reservation counties	10% threshold	40% threshold
All	–0·040* (–0·067 to –0·012)	–0·047* (–0·077 to –0·018)	–0·042* (–0·074 to –0·011)	–0·043† (–0·078 to –0·009)	–0·050* (–0·080 to –0·019)
Male	0·001 (–0·041 to 0·042)	–0·002 (–0·039 to 0·036)	0·003 (–0·033 to 0·039)	–0·020 (–0·061 to 0·020)	–0·012 (–0·050 to 0·027)
Female	–0·081* (–0·120 to –0·042)	–0·093* (–0·138 to –0·048)	–0·088* (–0·134 to –0·042)	–0·067† (–0·118 to –0·015)	–0·088* (–0·134 to –0·042)
Age >40 years	–0·038* (–0·066 to –0·010)	–0·052* (–0·082 to –0·022)	–0·039† (–0·071 to –0·007)	–0·042† (–0·078 to –0·006)	–0·051* (–0·082 to –0·019)
Sample size	9108	4968	7728	9108	9108

Poisson coefficients shown. 95% CIs based upon SEs clustered at the county level shown in parentheses. Models include unemployment rate, log snowfall, an indicator variable for the Sturgis Motorcycle Festival, an indicator for whether college was in session in the four counties with substantial student populations, a fifth order polynomial of first-time driving under the influence arrests to proxy for enforcement, per capita vehicle miles travelled (for external injury and total deaths only), per capita police officers, per capita on-premises and off-premises alcohol outlets, demographic characteristics including log of total population, share of males aged 18–40 years, share of males 60 years or older, share of females 60 years or older, share white, county-fixed effects, and year–month fixed effects. *p<0·01. †p<0·05.

Table 3: Robustness results for total mortality (Jan, 2000, to June, 2011)

respect to county-level reductions in arrests for repeat drunk driving, arrests for domestic violence, and traffic accidents among males.[19]

A potential factor that also needs further research could be the contribution of spillover effects that affect non-participants. A well publicised programme such as 24/7 Sobriety, which imposes considerable consequences, increases the perceived risks and costs of drinking and so might promote a general deterrent effect. Another potential mechanism is a reduction in drinking-related problem behaviours among participants, which might reduce mortality among non-participants (eg, domestic violence). With respect to circulatory deaths among women, one might consider reduced stress due to partner's cessation of heavy drinking. There might also be spillovers due to changes in the drinking behaviour of participants' family and friends. A husband's drinking affects his wife's drinking during the transition into married life and early in the marriage, and transitions in drinking behaviour can have spousal effects even later in life.[26,27] Evidence exists that an individual's drinking behaviour is affected by peers among college students,[28] by siblings, and by social networks.[29] Whereas these hypotheses might plausibly contribute to the large estimates, our ability to further refine the estimates and understand the mechanisms through which 24/7 Sobriety might affect mortality is restricted by our reliance on aggregate data. In the absence of a randomised controlled trial, we rely on quasi-experimental methods that might not address all potential confounders.

One concern with this approach is whether 24/7 Sobriety's implementation was coincident in each county with other factors that might affect mortality. For example, if record-keeping among public health officials with respect to alcohol improved as 24/7 Sobriety was implemented, we might see spurious links between implementation and outcomes. However, record-keeping changes seem unlikely given that ICD-10 coding remained the same throughout the period. Moreover, the dependent variables are based on the cause of mortality without conditioning on whether alcohol was a factor to avoid issues with inconsistent reporting that might or might not be related to

programme implementation and awareness. To the extent possible, we attempt to control for time-varying county factors (see appendix for graphs of related factors and issues), but cannot account for unobservable time-varying factors that might be correlated with implementation.

Because we estimate the association at the aggregate county level rather than at the participant level, our estimates could include any direct effects on programme participants, any general deterrent effect on non-participants who might wish to avoid the programme, and effects on others who would have been affected by the behaviour of drinkers, to the extent that such effects exist.

During the study period, 24/7 Sobriety participants were mainly monitored for alcohol use; a small subset were also monitored for drug use through urinalysis and drug patch testing. Existing programmes vary in the extent to which they emphasise drug versus alcohol abstinence, and whether it is best for programmes to simultaneously monitor several substances rather than focus on a single substance remains an open question.

Understanding the precise size of mortality reductions and the pathways through which 24/7 Sobriety affects mortality needs further research, particularly on how 24/7 affects participants and non-participants. Useful extensions of this work include randomised controlled trials and analyses of individual-level data on participation and mortality by specific cause. Such work might also consider longer follow-up on individuals to understand drinking patterns after participation ends given that alcohol dependence is often a lifelong and chronic condition. Individual-level analyses can also provide further insights into whether and how some groups, such as women, might be disproportionately affected.

Should a negative association be replicated in further work using experimental methods, other data sources or other jurisdictions, it would represent a significant advance in our understanding of how criminal justice interventions might be used to shape public health. More generally, this work adds to the growing body of evidence suggesting that policy interventions that alter heavy drinking among at-risk populations might have appreciable effects on

mortality. Additional work considering how well such programmes might work for other substances beyond alcohol would also prove useful.

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