

Effect of Community-Based Interventions on High-Risk Drinking and Alcohol-Related Injuries

Harold D. Holder, PhD

Paul J. Gruenewald, PhD

William R. Ponicki, MA

Andrew J. Treno, PhD

Joel W. Grube, PhD

Robert F. Saltz, PhD

Robert B. Voas, PhD

Robert Reynolds, MA

Johanna Davis, MS

Linda Sanchez, BA

George Gaumont, BS

Peter Roesper, MPH

ALCOHOL INTOXICATION INCREASES the risk of injury resulting from motor vehicle crashes and violent assaults.¹ There is increasing evidence of a causal link between the availability of alcohol and traffic crashes² and assaults³ in community settings. Previous evaluations of community-based programs to prevent alcohol-related injuries have focused specifically on fatal motor vehicle crashes⁴ or special populations, such as youth.^{5,6} We report an evaluation of a comprehensive, community-based environmental intervention to reduce rates of alcohol-related injuries resulting from motor vehicle crashes and assaults.

METHODS

A 5-year community alcohol trauma prevention trial was conducted from 1992 through 1996 to determine the effect of environmental prevention strat-

Context High-risk alcohol consumption patterns, such as binge drinking and drinking before driving, and underage drinking may be linked to traffic crashes and violent assaults in community settings.

Objectives To determine the effect of community-based environmental interventions in reducing the rate of high-risk drinking and alcohol-related motor vehicle injuries and assaults.

Design and Setting A longitudinal multiple time series of 3 matched intervention communities (northern California, southern California, and South Carolina) conducted from April 1992 to December 1996. Outcomes were assessed by 120 general population telephone surveys per month of randomly selected individuals in the intervention and comparison sites, traffic data on motor vehicle crashes, and emergency department surveys in 1 intervention-comparison pair and 1 additional intervention site.

Interventions Mobilize the community; encourage responsible beverage service; reduce underage drinking by limiting access to alcohol; increase local enforcement of drinking and driving laws; and limit access to alcohol by using zoning.

Main Outcome Measures Self-reported alcohol consumption and driving after drinking; rates of alcohol-related crashes and assault injuries observed in emergency departments and admitted to hospitals.

Results Population surveys revealed that the self-reported amount of alcohol consumed per drinking occasion declined 6% from 1.37 to 1.29 drinks. Self-reported rate of "having had too much to drink" declined 49% from 0.43 to 0.22 times per 6-month period. Self-reported driving when "over the legal limit" was 51% lower (0.77 vs 0.38 times) per 6-month period in the intervention communities relative to the comparison communities. Traffic data revealed that, in the intervention vs comparison communities, nighttime injury crashes declined by 10% and crashes in which the driver had been drinking declined by 6%. Assault injuries observed in emergency departments declined by 43% in the intervention communities vs the comparison communities, and all hospitalized assault injuries declined by 2%.

Conclusion A coordinated, comprehensive, community-based intervention can reduce high-risk alcohol consumption and alcohol-related injuries resulting from motor vehicle crashes and assaults.

JAMA. 2000;284:2341-2347

www.jama.com

egies on alcohol-related injury in 3 intervention communities. The intervention and comparison communities were each approximately 100 000 in population in northern California, southern California, and South Carolina. The communities were racially and ethnically diverse and incorpo-

Author Affiliations: Prevention Research Center, Pacific Institute for Research and Evaluation, Berkeley, Calif (Drs Holder, Gruenewald, Treno, Grube, and Saltz, and Messrs Ponicki and Roesper); Pacific Institute for Research and Evaluation, Landover, Md (Dr Voas); Pacific Institute for Research and Evaluation, Rockville, Md (Mr Reynolds and Ms Davis); PARTS, Salinas, Calif (Ms Sanchez); and Prevention Research Center, Pacific Institute for Research and Evaluation, Oceanside, Calif (Mr Gaumont).

Corresponding Author and Reprints: Harold D. Holder, PhD, Prevention Research Center, 2150 Shattuck Ave, Suite 900, Berkeley, CA 94704 (e-mail: holder@prev.org).

rated a mix of urban, suburban, and rural settings.

Designed to act synergistically to reduce alcohol-related injury and trauma, the 5 prevention components at each intervention site attempted to (1) mobilize the communities to support the preventive interventions through the formation of community coalitions and the use of media advocacy; (2) assist alcohol beverage servers and retailers with alcohol consumed on the sites of the bar or restaurant, ie, on-site drinking, as well as in developing and implementing beverage service policies to reduce intoxication and driving after drinking; (3) reduce underage access to alcohol by training of retailers who sell alcohol for consumption away from the retail outlet, ie, off-site drinking, and increased enforcement of underage sales laws; (4) increase actual and perceived risk of apprehension while driving after drinking through enhanced enforcement efforts such as roadside checkpoints and use of passive alcohol sensors; and (5) assist communities in developing local restrictions on access to alcohol through local zoning powers and other municipal controls on outlet density. Evidence regarding the efficacy of each component had been obtained in prior community studies⁷ but the components had never been used together within a comprehensive program intended to reduce alcohol-related injuries. Thus, the trial focused on changes in the social and structural contexts of alcohol use that would alter acute heavy drinking, which, in turn, would reduce injury and death.

After initial implementation, comparisons between interventions and matched comparison communities showed that the project (1) increased media attention to alcohol issues relative to comparison communities when estimated levels were converted to z scores (community mobilization⁸); (2) altered responsible beverage service policies at bars and restaurants by training 409 managers and servers, largely from establishments targeted based on their alcohol sales volume (responsible beverage service⁹); (3) reduced successful

underage purchase of alcohol from 44% to 17% (underage drinking¹⁰); (4) expanded enforcement of drinking and driving laws by establishing 410 sobriety checkpoints (drinking and driving¹¹); and (5) implemented stricter zoning restrictions in 2 of the 3 communities while closing several problem outlets (alcohol access¹²).

Intervention Stages

The interventions were implemented in 6 successive stages in each of the intervention sites (TABLE 1). The intensity of phase 1 activities was indexed by the rate of use of newly provided breath testing devices by police departments (reflecting the prominence of the drinking and driving component during this phase). Phase 2 activities were indexed by the rate of use of police roadside checkpoints for detecting drinking and driving (coordinated with increased license review and regulation of the alcohol access component). Phase 3 activities were indexed by the rate of police-administered on-site stings for enforcing responsible beverage service practices (coordinated with on-site trainings of the responsible beverage service component). Phase 4 activities were indexed by the rate of off-site trainings offered to establishments in each site (coordinated with off-site underage sales stings of the underage drinking component). Given the fine temporal grain of the alcohol-related crash and archival hospital discharge injury data (see below), these indices were used as constructed in analyses of these outcomes. The dates of onset of each phase of activity in each experimental site were used to form intervention pulses, which are variables that represented the period before and after the onset of intervention activities.

Data Acquisition

It was hypothesized that the interventions would modify alcohol consumption patterns, such as binge drinking and driving after drinking, which would result in reductions in alcohol-related traffic crashes and assaults. Therefore, outcome measures were selected to

reflect both drinking and alcohol-related injuries.

Based on an earlier assessment of the statistical power needed to detect effects of the interventions on alcohol consumption, approximately 120 general population telephone surveys per month of randomly selected individuals from households in each intervention and comparison site were completed over 66 months. Each community was defined by a set of ZIP codes and respondents were screened for household membership within these areas. Samples of random-digit dialing telephone numbers (replicates) were released for interviewing each week, with all numbers called, households screened for participation, and interviews conducted within 30 days' time (including initial calls, call backs, household screens, respondent selection, and interviewing). On contact, interviewers enumerated household members aged 18 years or older, and 1 adult member of the household was randomly selected for the interview. Completion rates ranged from 78% to 82%, and response rates ranged from 58% to 67% (completed surveys divided by known eligible respondents), across the years of the survey (full details on sampling procedures, weighting adjustments, and measures of response rates appear in related publications).¹³⁻¹⁵

Six self-reported measures were obtained from the general population survey. Within every 3 months of the survey, the proportion of respondents who reported alcohol consumption was assessed. Among persons who drank, self-reports of the average frequencies of drinking were obtained and quantities consumed per drinking day were estimated on the basis of responses to a series of drinking questions (ie, numbers of occasions drinking 2, 3, 6, and 9 or more drinks). Since drinking quantities vary over time and these variations are directly related to probabilities of heavy drinking, variances in drinking quantities were also estimated from the continued drinking data (notably, the greater the variance in drinking quantities, the greater the likelihood of alcohol-related

trauma).^{13,15} These estimates rely on a specific data acquisition system and mathematical model of drinking that has been shown to represent more comprehensively the range of drinking patterns exhibited in human populations.¹⁵ Frequencies of driving while intoxicated were obtained from answers to a question about the number of days in the past 6 months a person had driven after having had "too much to drink." Frequencies of driving when over the legal limit were obtained from responses to a question when the respondent felt he/she had driven when "over the legal limit." Responses to all items were averaged across respondents within every 3-month period and communities.

Traffic record data on motor vehicle crashes were collected from all sites from

January 1988 through December 1996. These data were obtained from the California Statewide Integrated Traffic Reporting System and the South Carolina Department of Public Safety. Monthly aggregate crash rates were estimated for each community for 3 different types of crashes: nighttime injury crashes (8 PM to 4 AM), all crashes in which the driver was cited for driving under the influence (DUI) of alcohol and, as a control, daytime crashes (4 AM to 8 PM), which are rarely alcohol-related.^{2,16} Driving after drinking crashes can reflect local police enforcement practices, but they have been shown to follow the trends of alcohol-related crashes measured independent of law enforcement.^{1,17} Nighttime crashes have consistently been shown to be alcohol-related.^{1,16-18} Each

crash series was adjusted for change in population size using annual estimates from the California Department of Finance and National Planning Associates Data Services, Washington, DC.

Emergency department (ED) surveys were conducted in 1 intervention-comparison matched pair (northern California) and 1 separate intervention site (South Carolina). Permission to conduct ED surveys at the hospitals in other sites could not be obtained. The EDs were attended by interviewers on a weekly or biweekly basis (depending on site) on Friday and Saturday evenings from 9 PM to 2 AM. Over the course of the study, 7817 injury cases were admitted to the EDs and 5941 interviews attempted. Interviews were not attempted for 24% of the admissions

Table 1. Implementation Phases of the Community Trials Interventions*

Intervention	Preintervention, April 1992 to June 1993	Phase 1, July to December 1993	Phase 2, January to December 1994	Phase 3, January to March 1995	Phase 4, October to December 1995	Postintervention, January to December 1996
Community mobilization	Local staff development and technical assistance Community coalitions initiated	Component task force organized Media mobilization efforts to draw attention to problems	Continued local activity	Continued local activity	Continued local activity	Continued local activity
Risk of drinking and driving		Support of city councils and police departments obtained Police equipped and trained for special DUI patrols Special DUI patrols begun	Full enforcement of activities in place with random roadside checkpoints	Continued local activity	Continued local activity	Continued local activity
Access to alcohol		Support of city councils and planning and zoning departments obtained	Restriction on alcohol availability at special events Beginning of intense license review, denials, and revocations	Initiation of new licensing regulations with planning and zoning department	Implementation of new distance regulations between outlets and public places (eg, schools, parks)	Continued local activity
Responsible beverage service			Local responsible beverage service implementation designed	On-site server training programs begun On-site stings begun	Continued local activity	Continued local activity
Underage drinking				Off-site server training programs begun Youth access surveys begun and results fed back to communities	Police enforcement operations against underage sales	Continued local activity

*DUI indicates driving under the influence of alcohol.

due to sudden rushes of ED arrivals (injury cases often coming in clusters). Of attempts, 17% refused and 24% could not be interviewed due to transfers to other hospital services for additional care (an overall response rate of 58%).¹⁹

Completed interviews included a breath test of blood alcohol content and an assessment of the cause of injury as reported by the person being interviewed. An average of 55 ED injury patient admissions were interviewed in each 6-week period in each site, 19% of which were related to violent assaults (approximately 10). In general, the proportion of positive blood alcohol content levels was greater among assault than motor vehicle injury cases (means of 0.003 vs 0.001 g/dL, respectively), but there were too few observations per period for time series analysis of alcohol-related assaults alone. As a consequence, the ED analyses focused on 1 outcome: number of injury assaults per 6-week period. The ED studies have demonstrated strong relationships between drinking and violent assault injuries.²⁰ Supplementary analyses revealed that respondent attrition did not bias estimated intervention effects and that alcohol was involved in far more assaults than can be attributed either to background demographic characteristics or drinking patterns.¹⁹

Archival hospital discharge data were used to measure the observed number of assault cases admitted into hospitals every month from each community. As such, the measure of assault injuries here refer only to those more serious assault cases that resulted in at least 1 overnight stay at the hospital. Since reports of assault rely on the availability of cause of injury codes (E-codes),¹⁹ and these were unavailable from the South Carolina sites, only 2 matched intervention-comparison pairs could be used in these analyses. However, since these data were collected from the much larger geographic areas of whole communities, overall the average numbers of assault cases measured in this way were much greater than those measured in individual EDs (approximately 46 per site per month).

Analysis Design

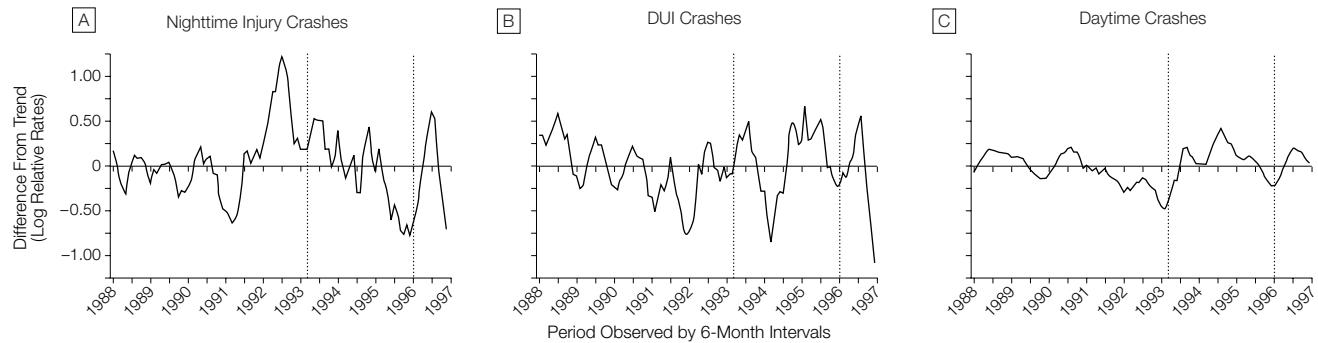
This evaluation used a longitudinal multiple time series design across the 3 intervention communities. The matched comparison communities served as controls.²¹ Within this design, the effects of project interventions can be determined by departures of intervention from matched comparison community outcomes.²² Thus, the majority of analyses relied on the advantages of the matched design by examining changes in the logged relative ratios of outcome measures in intervention vs comparison communities over time. Using logged relative ratios, negative values indicate a decrease in the rates of each outcome in the intervention vs comparison community and positive values indicate an increase. Seemingly unrelated regression equation models were used to simultaneously analyze the data from the 3 resulting series. In essence, changes in the 3 relative ratios were tracked over time and regressed over variables indicating the onsets of the 4 intervention phases. Separate regressions for each intervention-comparison pair could have been executed but would not provide an overall test across sites of the effects of the interventions. Seemingly unrelated regression equation models enable this test by allowing the comparison of intervention coefficients across matched sites under conditions in which it is assumed that there were no intervention effects (regression coefficients $\beta=0$ representing no differences between pairs for all 4 intervention series, $df=4$). A Wald statistic was used to assess the statistical significance of the combined impact of the interventions on experimental vs comparison community outcomes. This combined test also provided an assessment of the direction and overall effect size of intervention impact (a β value constrained to equality across treatments within intervention vs comparison sites).²² A full set of sociodemographic covariates was included in supplementary analyses of data from the general population random-digit dial survey. These results were

negligibly different from those reported here.

RESULTS

FIGURE 1 and FIGURE 2 present the logged relative rates in the intervention vs matched comparison sites for nighttime injury crashes, DUI crashes, daytime crashes, hospitalized assault cases, and proportion of violent assaults observed in the EDs. TABLE 2 shows reductions in drinking quantities, variances in drinking quantities, and self-reports of rates of driving when having had too much to drink or over the legal limit. While a statistically significant increase in the proportion of respondents who reported drinking in intervention vs comparison sites (from 65% to 66%) was observed, this increase was accompanied by substantial decreases in average quantities of alcohol consumed per occasion and variances in drinking quantities per occasion, measures that reflect heavy drinking. Adjusted mean quantities consumed decreased from 1.37 to 1.29 drinks per occasion, and the variance in average drinks per occasion decreased from 2.20 to 1.74. The observed reduction in heavier drinking levels was accompanied by reduced self-reported frequencies of driving when having had too much to drink and driving when over the legal limit. Adjusted mean frequencies of self-reported driving when having had too much to drink decreased from 0.43 to 0.22 times per 6-month interval. Adjusted mean frequencies of self-reported driving when over the legal limit decreased from 0.77 to 0.38.

Rates of nighttime motor vehicle crashes decreased significantly (Figure 1) in response to the onset and continued application of the interventions. There was a 10% decrease in the number of nighttime crashes per month in the experimental communities relative to expected rates from comparison communities. Reflecting this, there was also a 6% decrease in monthly rates of DUI crashes in experimental vs comparison communities transiently observed during and after the active in-

Figure 1. Crashes: Nighttime Injury, Driving Under the Influence (DUI) of Alcohol, and Daytime

To delineate the effects of the interventions from historical time trends, A, B, and C present detrended differences between intervention and matched comparison sites over time. The left dotted line is the point of initiation of the first intervention and the right dotted line is the point at which all interventions were active in all intervention sites. Values in A, B, and C are from January and July in each year at 3 experimental and 3 comparison sites.

intervention phase. In contrast, there was no decline in daytime motor vehicle crashes.

Assault cases in the ED (northern California sites only) declined at the onset of the program, and hospitalized assault cases declined after full program implementation (Figure 2). Using data directly obtained in EDs in the northern California intervention and comparison sites, the decline was 43% (ED admissions per 6-week intervals in experimental relative to comparison sites). Hospital assault cases resulted in lower observed declines in assault rates (numbers per month declining 2% in intervention relative to comparison sites). This later effect on hospitalized assaults is likely due to the accumulated effects of the program (reaching full implementation in January 1996) and the spread of program effects throughout the intervention communities over time. The ED reduction in the northern California sites is consistent with the observed reduction in heavy drinking events in that community (reflecting the contribution of alcohol to violence-related injuries), as well as heavy drinking in all communities.

COMMENT

Evaluations of community prevention programs take place within complex community systems. Residents of communities are influenced by a variety of

Figure 2. Proportion of Assaults Observed in Emergency Departments (EDs) and Hospitalized Assault Cases

To delineate the effects of the interventions from historical time trends, A and B present detrended differences between intervention and matched comparison sites over time. The left dotted line is the point of initiation of the first intervention and the right dotted line is the point at which all interventions were active in all intervention sites. Values in A are from 1 experimental and 1 comparison site. Values in B are from January and July in each year starting with July 1990 and are from 2 experimental and 2 comparison sites.

intrinsic and extrinsic forces that affect their drinking behaviors. These include demographic characteristics that appear related to drinking patterns; characteristics of the local retail market that distributes alcohol; the management systems of retail establishments; enforcement systems responsible for laws regarding sales, distribution, and use of alcohol; and the media that report on all this activity and can be called on to support preventive interventions. Thus, any evaluation of preventive interventions to reduce alcohol-related trauma in community settings is difficult and subject to many local in-

fluences. The preponderance of results from the current study strongly support the observation that environmental prevention programs can work to reduce alcohol-related injury and accidents in community settings.

As an environmentally based prevention trial, the prevention strategies did not target general drinking per se. Indeed, the percentage of persons who reported drinking in the intervention communities contrasted with the comparison communities actually increased (2%) during this trial and the frequency of drinking did not change. The major intermediate effects of this

trial on drinking were reduced levels of self-reported alcohol consumption (in terms of average drinking quantities, -6%) and reduced variability in the self-reported amounts consumed per drinking occasion (ie, a 21% reduction in high-variance drinking). Thus, drinking patterns most likely to be antecedents to alcohol-related trauma were modified. That is, self-reported binge drinking, as measured by volume and variance, declined while the percentage of persons who reported drinking slightly increased, suggesting that alcohol-related injury rates may be reduced by modifying drinking patterns without preventing alcohol consumption altogether. This is consistent with the broader literature on binge drinking, which has linked such drinking to drinking problems and other high-risk behaviors.²³⁻²⁵

The intervention further demonstrated a reduction in nighttime injury crashes even as daytime crashes remained unchanged. After implementing the interventions, we observed average monthly declines of 6% in driving after drinking crashes and 10% in night-

time injury crashes in intervention relative to the comparison communities. Maintained over the length of the postintervention period, these monthly reductions, based on average implementation levels, were related to reductions in rates of nighttime injury crashes by 56 per 100 000 adult population per year and reductions in rates of driving after drinking crashes by 67 per 100 000 adult population per year. Across the 3 communities, the total savings from the interventions were 186 nighttime injury crashes and 222 DUI crashes through the end of the postintervention period.

When controlling for background characteristics of ED injury cases, including patterns of drinking and routine drinking activities (eg, drinking at bars), violent assault cases have been shown to be uniquely related to alcohol.¹⁹ The analyses conducted for this article enabled a comparison of expected rates of assaults appearing in the ED relative to those observed after the intervention began. Compared with the expected postintervention rate of assaults appearing in 1 intervention site ED at

baseline (112 per year), the intervention reduced assault admissions to 64 per year, resulting in an accumulated reduction of 118 fewer assault cases through the postintervention period (68 per 100 000 adult population through December 1996). A limitation of the ED results is the availability in only 1 matched pair in northern California and a single intervention site in South Carolina. Limitation of the hospitalized assault cases is their availability in the 2 matched California pairs. However, both ED and hospital discharge results were consistent with each other and with the reductions in self-reported heavy acute drinking in all 3 matched pairs. Importantly, during the years of this study, the participating EDs provided emergency medical care only within the geographical service areas defined by the boundaries of this trial, and medical coverage did not change during study years as a result of managed care or emergency medical service policy.

Therefore, the results from the 3 levels of outcome data in this 3-community prevention trial provide evidence that environmental strategies can re-

Table 2. Intervention Results*

Data Source	Outcome Measure	χ^2	df	P Value	β	% Change (95% Confidence Interval)†
General population survey	Proportion drinking‡	10.354	3	.02	.0292	2 (0 to 4)
	Average drinking frequency§	4.170	3	.24	-.0012	-1 (-4 to 2)
	Average drinking quantity	11.907	3	.008	-.0672	-6 (-12 to -1)
	Average drinking variance	27.341	3	<.001	-.1144	-21 (-31 to -9)
	"Too much to drink" but drove	11.529	3	.009	-.3902	-49 (-70 to -11)
	"Over the legal limit" but drove	15.052	3	.002	.5123	-51 (-70 to -21)
Archival crash data, crashes per mo	Nighttime injury	13.601	4	.009	-.0173	-10 (-14 to -4)
	Alcohol-related	19.556	4	.001	-.0121	-6 (-8 to -3)
	Daytime	4.511	4	.34	.0423	2 (-7 to 14)
Archival hospital discharge data, discharges per mo	Emergency department assault cases¶	19.692	4	<.001	-.0160	-2 (-3 to -1)
Emergency department survey based on observed assault cases per 6-wk period	Proportion assaults#	9.496	4	.05	-.5623	-43 (-71 to 11)

*Data were based on information from 3 intervention communities and 3 comparison communities unless otherwise indicated.

†Measure relative to comparison sites through postintervention period (December 1996).

‡Proportion of population aged 18 years or older, consuming at least 1 drink in the past year.

§Number of days consuming 1 or more drinks within standardized 28-day period.

||Frequency over past 6 months.

¶Data were from 2 intervention and 2 comparison communities.

#Data were from 2 intervention communities and 1 comparison community.

duce alcohol-related traffic crashes and also injuries and violence associated with alcohol. By using 3 communities reflecting both East and West Coast locations, this trial confirms and extends the findings in reduction of traffic crashes from the Saving Lives program (all crashes) in Massachusetts⁴ and the Communities Mobilizing for Change on Alcohol program (youth only) in Minnesota and Wisconsin.⁶ While like the Woonsocket, RI project,^{26,27} this trial found changes in ED events, reductions in assault cases (both in ED and hospitalized cases) are the first such effects reported from a controlled community trial.

This trial has important limitations. The communities were selected because they were interested in testing environmental prevention strategies. While the nonrandom selection of intervention sites enabled an efficacy test of environmental prevention efforts, a test of the full generalizability of such interventions will require much larger effec-

tiveness trials. The current trial has limited generalizability beyond the 3 community-matched pairs that comprised the study. It should be noted that the community trial itself could introduce a social desirability bias, which could bias the self-reported data from the general population surveys. Thus, there is the potential for bias if the interventions influenced the self-reports of drinking. This would not bias the archival data used, however. Another limitation in use of traffic crash data is that alcohol-related crashes are a small percentage of actual drinking and driving events in the community. This increases the difficulty in evaluating the full effect of the interventions. While self-reported drinking measures and traffic crash data were consistently and reliably available across all 3 pairs, assault data were not. As a result, the generalizability of the assault reduction in particular should be tested in subsequent trials.

This large prevention trial shows that communities need not remain passive

recipients of trauma caused by heavy drinking. Whereas education and public awareness campaigns alone are unlikely to reduce alcohol-related injury and death in communities, when they are combined with the environmental strategies tested in this trial, mutually reinforcing preventive interventions can succeed. We believe the key is to use several mutually reinforcing strategies: media attention to alcohol problems, changes in alcohol serving practices in local bars and restaurants, reductions in retail sale of alcohol to young people, increased enforcement of drinking and driving laws, and reductions in the concentration of alcohol retail outlets. This trial was a multilevel approach in which special attention was given to the mutual reinforcement of these linked components.

Funding/Support: Research for and preparation of this article were supported by the National Institute on Alcohol Abuse and Alcoholism grant AA09146 and the Center for Substance Abuse Prevention.

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