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A Spatial Analysis of Student Binge Drinking, Alcohol-Outlet Density, and Social Disadvantages

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Abstract

Background and Objectives—This paper examined whether and how student binge drinking at the individual level was influenced by population disadvantages, community instability, alcohol-outlet density, and protective factors generated by community and school.

Methods—We used a dataset collected in 2002 by the Alabama Department of Mental Health, with additional materials generated by the 2000 Census and from the Alabama State Department of Education. School-catchments were employed as geographic units of analysis. The final sample comprised 78,138 public-school students in grades 6–12 who attended schools located in the 566 school-catchments.

Results—We hypothesized the presence of spatial processes that, once identified, would enhance understanding of student binge drinking. Our results confirmed that student binge drinking in a focal area was affected by that area's structural factors and also by individual-level risk and protective factors. The results did not support the hypothesized impact of surrounding areas' characteristics on student binge drinking in the focal area.

Conclusions and Scientific Significance—The results of our study clearly indicate that both environment-based factors and individual-level risk and protective factors are important in explaining student binge drinking in Alabama.

INTRODUCTION

Binge drinking, or episodic heavy drinking, has become common among young people in the United States, although this group includes many too young to drink legally¹. In a 2008 survey, 40% of college students, 26% of 12th-graders, 16% of 10th-graders, and 8% of 8th-graders reported participating in binge drinking within the past 2 weeks^{2, 3}. Binge drinking is often defined as consuming at least 5 alcoholic drinks in a row during the past 2 weeks; this is a definition endorsed by the Monitoring the Future Study^{2, 3}. Binge drinking has elsewhere been defined differently for males (5 drinks consumed within 2 hours) and females (4 drinks in 2 hours), reflecting the sexes' differential average body weight and metabolism⁴⁻⁶. Consuming such amounts so quickly, binge drinkers typically experience a rise in blood alcohol concentration to at least .08% (.08 grams of alcohol per 100 grams of blood), which is the point of intoxication at which it becomes illegal to operate a motor vehicle. Drunk-driving-related accidents and arrests are but one complication associated

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with binge drinking; others are sexual risk taking, fighting, injury from falls or the like, and impairment of physical health. This makes binge drinking a public health concern¹.

Binge-drinking behavior reflects individual-level risk and protective factors^{7, 8}, yet it also requires contextualizing. This is because binge drinking so regularly occurs in settings featuring groups of adolescents or young adults, clustering in particular geographic areas (and near particular schools) characterized by particular sets of structural factors and ecological conditions^{9–11}. In this study, we wanted to consider the role in students' individual-level binge-drinking behavior played by factors characterizing their school and community environments. Schools, of course, do not permit alcohol on their campuses, yet schools are pertinent here because the typical adolescent spends so much time at school. Specifically, we intended to examine whether and how Alabama public school students' behavior was affected by five things: alcohol-outlet density, population disadvantages, community instability, school and community protective factors, and individual-level protective factors and risk factors. We also intended to weigh the role of social ecology in students' drinking, evaluating the potential of environmental factors to spill over, via social and diffusion processes, from one specific geographic area to adjoining areas, shaping students' drinking¹².

Many studies of alcohol and drug use by adolescents and young adults have sought out individual-level risk and protective factors; findings have tended to confirm the importance of peer and family influences^{8, 13}. Drinking in adolescence and very young adulthood is widely considered to be inappropriate, even deviant, behavior. Thus it has been found to be affected by family, which provides social bonds and can instill conventional values; by friends, whose behavior and whose attitudes about substance use are influential; and by individual religiosity and moral values¹⁴. Individuals living in relatively disadvantaged neighborhoods with relatively many drinkers present are more likely than others to have friends tolerant of drinking; the influence of these friends may be strengthened when alcoholic beverages are readily available nearby¹⁵.

Adolescents' use of alcohol, however, is also shaped by broader social contexts in which they function^{16, 17}. Individual-level factors are in part a reflection of these contexts' characteristics. Indeed, the same individual-level factors may produce differential effects when at work in differential social contexts¹⁸. The characteristics of their schools constitute important contexts in which students develop—or do not develop—deviant behaviors like binge drinking^{19–21}. Geographic location is one such feature that shapes a school and its immediate community and may influence the power of individual-level factors. To answer the *why* of school students' binge drinking, then, it is necessary to simultaneously understand the *where*²².

For example, the availability of alcohol varies from place to place—that is, geographically—reflecting a spatial pattern as well as a social pattern^{23, 24}. In some neighborhoods more than others, adolescents find it easy to directly purchase alcohol in alcohol outlets (older peers may make the purchase, in some cases)^{25, 26}. Since adolescents tend to be comparatively confined when it comes to independent transportation, proximity of alcohol outlets is a crucial factor in their binge drinking^{1, 27}. Indeed, adolescents and adults alike drink more when the communities they live in host alcohol outlets in relatively dense numbers^{10, 28}. Dense alcohol outlets have also been linked to drunk driving, alcohol-related injury, and violence^{29–31}. Moreover, certain types of deviant behavior are statistically associated with the presence of bars (although not alcohol-serving restaurants) versus liquor or package stores. The former on-premises-consumption outlets can be hotbeds of public drunkenness and violent crime in public places, studies show; while the latter off-premises-

consumption outlets are linked to domestic violence and suicidal behavior in private dwellings^{1, 29, 32, 33}.

The literature strongly establishes a positive relationship between dense alcohol outlets and increased numbers of drinkers, as well as more individual-level drinking^{9, 32, 34}. To help theoretically link dense alcohol outlets to, specifically, increased binge drinking by adolescents, we can turn to 2 major social mechanisms. First, dense alcohol outlets in a community have been linked to severe social disadvantages within it, for instance to a high crime rate^{10, 31, 33, 35}. Dense alcohol outlets are rarely present in advantaged, wealthy neighborhoods, which tend to be carefully zoned, thanks to their residents' social capital and political power^{10, 36}. Areas most likely to feature dense alcohol outlets, in contrast, comprise the sphere of the single-mother household, of the minority ethnic group, the uneducated, the poor. In their neighborhoods, social disadvantages and alcohol outlets combine to generate opportunity for deviant drinking. Young people from these neighborhoods tend to meet together (as young people will do), not in homes or under auspices of afterschool programs, but in the street or at entertainment venues, bars, or restaurants³⁷. With alcohol comparatively readily available, and with peers comparatively likely to approve of underage drinking, these neighborhoods' young residents are, unsurprisingly, relatively likely to binge drink¹⁷.

A high level of social disadvantage and alcohol outlets in a community implies a corresponding low level of social control, or collective efficacy, constraining residents^{38, 39}. Strong collective efficacy is in effect when residents watch out for each other's property, children, and well-being, creating social cohesion⁴⁰. Where bars are numerous, nonresidents—strangers, perhaps potential criminal perpetrators—may be drawn to the area^{10, 33}, making it difficult for residents to provide each other guardianship, and especially to shield youngsters from engaging in deviance such as binge drinking^{33, 41}. Guardianship and collective efficacy are enhanced, in contrast, where young people of a community have many opportunities to exhibit and be rewarded for prosocial behaviors. Whether these opportunities come through school, civic/social clubs, or church, they can be considered protective factors countering social disadvantage and dense alcohol outlets⁴². That is, the school and the community *can* offer an environment that functions to curtail underage binge drinking.

THE PRESENT STUDY

The present study involved 2002 data from Alabama public-school students in grades 6–12 and developed a multilevel model incorporating environment-based and individual-level risk and protective factors to explain individual-level binge drinking. The model's first level evaluated the students' demographic factors, their friends' use of alcohol, their religious participation, their own approval or disapproval of substance use, and their family bonds. Each of these was characterized as either a risk or protective factor in binge drinking. Students' individual data remained, "nested," during the model's second-level analysis, which employed the *school-catchment* as the unit of analysis. A school is like any of its students in being susceptible to influence from the context it exists in, beginning with the neighboring community^{9, 43}. The school-catchment is the influential area neighboring a school and typically bounded by the school bus routes servicing the school. The school-catchment is, then, that area whose residents are authorized to use the school. (Beyond this neighboring community are other influences: A school's structure and culture stem from imposed educational policies and are moreover shaped by the sufficiency of resources granted to the school by those in power⁴⁴.) A school-catchment may well include alcohol outlets, and when these are distributed densely within the school-catchment, they should be associated with increased individual-level binge drinking by the school's students¹.

During the second-level analysis, the study hypothesized that environment-based factors affected individual-level binge drinking and, what's more, moderated the effects of individual-level risk and protective factors on binge drinking. Together, the two levels of analysis sought to explain students' binge drinking in terms of (a) the population disadvantages which indicate prevalent financial hardship characterizing a school-catchment's population; (b) community instability, indicating the degree of residential mobility in the school-catchment; (c) community alcohol-outlet density, describing the availability of alcohol in and near the community; (d) protective role of community, or how readily members of the community within the school-catchment encourage and reward student prosocial behavior; (e) protective role of school, or how readily teachers/staff and school-based groups encourage and reward student prosocial behavior; and (f) individual-level factors.

The study also hypothesized that *spatial externalities* would exist, which means that the binge-drinking rates characterizing one school-catchment would to a certain extent describe whatever other school-catchments abutted it¹². In other words, students' binge drinking would be affected by environment-based factors characterizing not only their immediate community but adjacent communities as well³³. The present study measured some such factors—alcohol-outlet density, population disadvantages, instability, and community and school protective factors—but there may be more. By modeling spatial externalities, we positioned the analysis to capture the observed and unobserved factors.

A threefold contribution to the literature resulted from the present study. First, its findings involve both individual behavior and the role of the social context. Binge drinking is usually acknowledged to be dangerous, threatening serious injury and even death, as well as illness and academic failure⁴⁵. Full understanding of why students binge drink when the behavior is so risky calls for interdisciplinary examination of both individual- and contextual-level factors⁴⁶. Second, the present study's multilevel model allowed us to ask whether and how the geographic location of a school-catchment (the *where*), in tandem with certain social factors (the *why*), facilitated student binge drinking. Earlier researchers, of course, used both geography and the university social environment in explaining individual- and collective-level substance use (as well as criminal behavior) by collegians^{43, 47, 48}. However, we believe the present study is the first to set out to analyze school-catchments' where and why factors simultaneously. Third, the present study postulated theoretical explanations of the well-established links between alcohol-outlet density and alcohol consumption³³, following up the resulting line of thought with empirical tests exploring whether social disadvantage, as well as communities' and schools' protective roles, might provide the social mechanisms underlying those established links.

METHODS

The data for the present study came from several sources, all linked to the State of Alabama. The Substance Abuse Services Division (SASD) of the Alabama Department of Mental Health (ADMH) was one source. In 2002, the division conducted the Alabama Student Survey as part of a prevention-needs assessment project⁴⁹. The survey's target population was students enrolled during spring 2002 in Alabama public schools in grades 6–12. Schools chosen for the SASD research numbered 812, covering all Alabama counties. The survey elicited a school response rate of 73% and a student response rate of 77%⁴⁹. The address of each participating school was obtained from the Alabama State Department of Education website (<http://www.alsde.edu/html/home.asp>) and geocoded for data analysis.

The geographic unit considered in the present study was the school-catchment, which included 1 public school plus its catchment area (see Figure 1, a map of school-catchments

in Alabama). A school's catchment is the area from which students are assigned to that particular school. The catchment is bounded by its school bus routes through the surrounding community, routes servicing the families using the particular school. Two (or more) schools participating in the SASD survey and housing different grades could share a single catchment. It was also possible for a single school to draw students from more than one catchment, depending on the range of grades housed within the school. That is, different grade levels could have different school-catchments. We considered both specific schools *and* specific grade levels, then, as we determined the composition of each of the school-catchments constituting our geographic units. The data from each distinct school-catchment contextualizes any student binge drinking within it.

Maps of the boundaries of Alabama public school catchments were not readily available for this research, although we contacted each school to request catchment maps and/or school bus routes from which catchments could be mapped. When a school did provide a map or bus routes, we used Geographic Information Systems (GIS) techniques to plot its school-catchment in digital form. GIS techniques also allowed us to estimate the catchments of schools not providing a map or route information, based on the assumption that all students were assigned to the closest school. This assignment was carried out by measuring the highway distance from the center point of each census (the smallest zones used by the Census Bureau) to the nearest school with a particular grade level and then assigning each block to the nearest school. When spatially aggregated these areas represented an approximation of each school's catchment area for a particular grade level.

Because (in order to explain student binge drinking) we wanted to know the structural characteristics of the catchment communities, we then linked our school-catchments to standard census units. Where a school-catchment did not align with standard census units, we employed GIS techniques to interpolate the structural characteristics using an areal weighting approach. In brief, we used a proportional aggregate of official census measures pertaining to the school-catchments, laid out to compute the structural characteristics included in the present study. Assume, for example, that 1 school-catchment subsumes 5 census tracts, and the school-catchment is laid out so that 20% of it lies in census tract I and other, different percentages lie in tracts II–V. As we measured (*prior to* data analysis, and using census data) the variables for a given school-catchment community, we adjusted each value to reflect the percentage of the school-catchment (our geographic unit of analysis) contained in the particular census tract.

Measures

Individual-Level Variables—Using students' self-reports from the Alabama Student Survey, we measured frequency of binge drinking by counting the occasions, within the past 2 weeks, on which an adolescent had consumed 5 or more alcoholic drinks within a span of 2 hours. This time period was short, far more restrictive than that employed by the Monitoring the Future study to define binge drinking. Response categories included 1 (*0 occasions*), 2 (*1–2 occasions*), 3 (*3–5 occasions*), 4 (*6–9 occasions*), 5 (*10–19 occasions*), 6 (*20–39 occasions*), and 7 (*40 or more occasions*). Strongly positively skewed data resulted, since a majority of students reported they had not engaged in binge drinking or had done so on no more than 1–2 occasions during the specified period. For this reason, we subsequently used log transformation when measuring the binge-drinking variable, obtaining a continuous variable that was less skewed (LnBinge). Our individual-level variables included as well 3 protective factors, 1 risk factor, and demographic variables. The protective role of religion was measured using students' reports of their attendance at religious services or activities; offered responses ranged from 1 (*never*) to 4 (*about once a week or more*). We constructed an index to measure the protective role of family. The index represented family-based

opportunities and rewards for prosocial involvement, as well as the adolescent's attachment to parents. It asked students how strongly they agreed with statements concerning their involvement in family decisions and activities; the help available from their families when facing problems; their enjoyment of time spent with parents; parents' expression of praise and approval; their feelings of closeness to parents; and the sharing of thoughts within the family (Alpha = .89). The protective role of the self was also measured using an index. This index asked how strongly students agreed with statements about their honesty with parents (even when serious consequences loomed); their honesty on school work; and their perception of the riskiness of illegal drug use (Alpha = .80). Concerning our family index and self index, frequently, the items' own particular response scales were dissimilar, making standardization of both indexes important. To standardize an index, first we rendered all the items it comprised as *z*-scores. Then, we summed each index's associated *z*-scores.

Our risk factor peer drug use measured the number of a student's best friends who used cigarettes, alcohol, marijuana, and/or other drugs, for instance LSD or cocaine (Alpha = .82). Our demographic variables were gender, measured as a dichotomous variable (1 indicating male), and grade, measured as a continuous variable, from 1 (*6th grade*) to 7 (*12th grade*). The Alabama Student Survey requested race and ethnicity data, but to protect confidentiality, the dataset provided to us did not include this data. Of students reporting their race or ethnicity, 64.2% were white, 28.8% were African American, and 7% were other (Hispanic, Asian, Native American, or Pacific Islander)⁴⁹. These statistics aligned well with official enrollment statistics for 2001.

School-Catchment-Level Variables—To contextualize student binge drinking by school-catchment, during the second-level analysis we included the protective role of school, the protective role of community, and a list of structural variables reflecting population disadvantages, community instability, and alcohol-outlet density. The protective factors reflect collective actions taken by a school or community to promote student prosocial behavior. Protective role of school and protective role of community were measured through individual students' responses to Alabama Student Survey items. Previous studies have linked structured school activities and extracurricular participation at school to adolescents' positive development. The two lead to, specifically, a sense of belonging at school, a sense of self-worth, the presence of supportive teachers and peers, and social and academic gains^{50, 51}. We classified five things as prosocial activities: class projects, group decisions, extracurricular activities, notice or praise from teachers, and a feeling of safety at school. We quantified responses to several survey items asking students if they agreed prosocial opportunities and rewards were available at their schools through these five. First, we constructed an index that summed each surveyed student's scores for the five; then, we aggregated and averaged the sums, moving the measure from the individual level to the school level⁴².

To measure the protective role of the community, first we captured individual responses indicating adolescents agreed (or disagreed) that adults were available to talk with; sports teams and social clubs offered constructive ways for them to spend time; and their neighbors encouraged, noticed, and were proud of their accomplishments and good qualities. As before, these individual responses were aggregated and averaged to produce the community-level measure. Mean substitution was used to rectify any missing data describing 5 of the variables, namely peer drug use, protective role of self, protective role of family, protective role of school, and protective role of community.

The density of alcohol-sales outlets in each school-catchment measured a community-contextual risk factor, since easy availability of alcohol increases opportunities for students to drink. Using GIS techniques and alcohol-outlet street addresses that we geocoded, we

determined for each square kilometer (1 kilometer² = .39 mile²) the number of (a) bars, (b) retail stores, and (c) restaurants offering patrons alcoholic beverages; this measured the alcohol-outlet density of each school-catchment. The Alabama Alcohol Beverages Control Board provided us with the addresses of all on- and off-premises alcohol outlets licensed during 2001 and 2003 (approximately contemporaneous with the 2002 administration of the Alabama Student Survey). Ultimately, we obtained an average of the number of outlets licensed during the 2 years; overall, a geocode rate of 77% was obtained.

We measured the following structural characteristics for each school-catchment: percentage of African American residents in 2000; percentage of White residents in 2000; percentage of female-headed single-parent families (children under age 18) in 2000; percentage of population living below poverty level in 2000; school-catchment's location in a "Black Belt" county; percentage of population 15–18 years old in 2000; percentage of families residing in one and the same domicile from 1995 to 2000; percentage of population 25 years and older having a college degree in 2000; percentage of population 25 years and older having a high school diploma; school-catchment's location in a "dry" county; and percentage of population that was urban in 2000. To preserve parsimonious measures and avoid multicollinearity during data analysis, we conducted exploratory factor analysis, categorizing the 11 structural characteristics and 3 alcohol-outlet density variables into 3 constructs: population disadvantages, community instability, and alcohol-outlet density.

To obtain the 3 constructs, we added together standardized scores for the first 6 measures, then added together standardized scores for the final 5 factors, and then, separately, added together standardized scores for the 3 alcohol-outlet density variables—after recoding the data so that the "dry" county measure, percentage of White residents in 2000, and the 1 domicile 1995–2000 measure aligned in the same direction within each index. Some earlier researchers measuring the availability of alcohol have distinguished types of alcohol outlets, such as restaurants versus bars. In the present study, however, we opted to integrate outlet types (bars, retail stores, *and* restaurants) in a single index^{1, 33}. Our decision was prompted by our observation in *each* school-catchment of strong correlations among the three alcohol-outlet types. The Alpha for the population disadvantages measure was 0.92; for the community instability measure was 0.82; and for the alcohol-outlet density was 0.92. Earlier studies of drug use and other delinquent behaviors had drawn both on the Alabama Student Survey dataset and on several of the measures used in the present study^{14, 42}.

Data Analysis

Hierarchical linear regression analyses were first conducted to evaluate whether and how individual-level and environment-based factors affected our sample's binge drinking. Next, we combined spatial modeling techniques with the hierarchical linear regression techniques in a 2-stage least squares (2SLS) approach, developing a *hierarchical spatial model* of student binge drinking while estimating an autoregressive process characterizing binge drinking and evaluating whether observed/unobserved environment-based factors in one school-catchment affected surrounding school-catchments' binge drinking.

RESULTS

Table 1 and Table 2 present descriptive statistics for the individual-level and the environmental factors measured. The average number of binge-drinking occasions is slightly greater than 0. Our aggregated data showed a mean binge-drinking measure of slightly over 0 binge-drinking occasions, across the school-catchments. At the individual level, binge drinking was associated with students in higher grades, males, and respondents with weaker protective factors (religious attendance, protective family, protective self) and a relatively high level of peer drug use. Average student binge drinking in a school-catchment decreased

when the community and school encouraged prosocial behavior by their students. No significant correlation was found between student binge drinking and the 3 structural risk factors (instability, population disadvantages, and alcohol-outlet density). These structural risk factors were related significantly and inversely, however, to protective role of community. Community instability was also significantly and inversely related to protective role of school.

Using hierarchical linear regression, we developed 4 models we used to estimate the impact of environment-based and individual-level factors on frequency of student binge drinking. Table 3 illustrates our results.

Model I. Including only individual-level risk and protective factors, gender, and grade, the first model generated results demonstrating that higher measures of individual-level binge drinking tended to characterize students in higher grades who were male and relatively less religious. Such higher measures were also associated with students having relatively many drug-using friends and scoring lower on our measure of protective role of self. We also found that protective role of family increased student binge drinking.

Model II. By adding to Model I the main effects of the 5 second-level variables (community instability, population disadvantages, alcohol-outlet density, protective role of school, protective role of community), we developed our Model II. In Model II, with our school-catchment-level factors included, all individual-level risk factors and protective factors continued significantly affecting student binge drinking. The population disadvantages and community instability factors, however, did not prove significant in Model II, although alcohol-outlet density, protective role of school, and protective role of community were found to be significant. After controlling all individual-level factors, we observed an association between low levels of binge drinking and high measures for protective role of school and protective role of community. However, we also observed high alcohol-outlet density to be associated with reduced binge drinking by our sample. Comparing the variance components of Model I and Model II, we found that 27% of individual-level binge drinking was accounted for by the 5 school-catchment-level factors.

Model III. The factors protective role of community and protective role of school function as social-relationship factors at a collective level and may thus delineate social mechanisms that lead from structural disadvantages—population disadvantages, community instability, and high alcohol-outlet density—to student binge drinking. We therefore included in our Model III those interactions involving one of the 3 structural factors and one of the 2 protective factors. Results from this model offer evidence that, while population disadvantages and community instability lack significant independent effects on student binge drinking (as shown in Model II), these variables nevertheless chip away at protection generated by community encouragement of student prosocial behavior, reducing such encouragement's capacity to decrease binge drinking. The interaction involving instability and protective role of school yielded a significant negative coefficient; this shows the factor protective role of school was more likely to reduce student binge drinking in school-catchments exhibiting higher community instability.

Model IV. We wanted to outline how our social contextual factors might channel, through our individual-level risk and protective factors, any effects they wielded on student binge drinking. We therefore included interaction terms across the individual-level and school-catchment-level factors. To simplify our findings we included only the significant interaction effects, producing our Model IV. Here again we observed that the effects of each of our study's individual-level factors were significant.

As grade level increased, so did students' binge drinking. This association became even stronger among students living in neighborhoods with many population disadvantages and high alcohol-outlet density. Grade level's effect on binge drinking was reduced among students attending schools that encouraged prosocial behavior. While more binge drinking was observed in male students, the gender gap narrowed as the measure recorded for protective role of school increased. Increased community instability reduced the protective role of religion against student binge drinking. In addition, population disadvantages enhanced the positive effect on student binge drinking wielded by presence of drug-using friends. Protective role of self strongly reduced levels of student binge drinking in our analysis, but the impact was diminished significantly in the presence of any of the following: relatively strong protective role of school, relatively strong protective role of community, instability, and numerous population disadvantages.

Model IV's significant interaction effects suggest moderating roles for the 5 environment-based factors, in the relationships between individual-level risk/protective factors and student binge drinking. Comparing Model IV's variance components to those of Model I, we found environment-based factors to explain 33% of the variance in grade level's effect; 25% of the variance in gender's effect; 5% of the variance in religion's protective effect; and 32% of the variance in the self's protective effect. Furthermore, our final model accounted for 37% of the explained variance in student binge drinking.

Spatial Analysis Results

Students' drinking practices, as currently understood, are shaped by individual-level risk and protective factors; by structural and social-relationship factors in their school-catchment communities; and by such factors in their broader communities (areas surrounding school-catchment communities). The present study hypothesized that similar binge-drinking behavior would cluster in groups of contiguous school-catchments. To test this hypothesis, we looked for spatial interdependence in our model, asking whether spatial regression featuring a spatial lag variable would help explain students' drinking.

The present study assumed spillover of binge-drinking behavior—via social and diffusion processes—from one school-catchment to its adjacent school-catchments. We also assumed that relatively pronounced spillover effects would be found on binge drinking among students living in a school-catchment adjacent to a neighboring catchment with a higher average level of binge drinking, Y . We defined neighboring community as a school-catchment adjacent to the immediate community. Typically, more than one neighboring community adjoins the immediate neighborhood. The spatial lag variable of the binge-drinking outcome (W_y) and the spatial lag variables of the structural and social-relationship factors (W_x 's), therefore, should be obtainable for each school-catchment, using the Rook definition. When data were missing for an adjoining school-catchment, as when that area fell outside Alabama state lines, we calculated (i.e., estimated) the spatial lag variable using only data available from Alabama.

In conducting spatial analysis, we first used hierarchical linear regression to calculate mean measures of student binge drinking, adjusting for individual-level factors in each school-catchment. The equation generating the mean measures of student binge drinking adjusted to each school-catchment (Y^*) was $Y^* = Y_j - \text{Mean } Y - (\text{Fitted } Y)$. To obtain Fitted Y , we ran the hierarchical model of binge drinking with only the individual-level covariates, which are centered around their school-catchment means. Mean Y is the average student binge drinking; Y_j is obtained by aggregating and averaging student binge drinking for each school-catchment. Adopting the 2-stage least squares approach¹², we used the first stage to remove the correlation between W_y and the error term of the binge-drinking variable, by including all the spatial lag terms of the independent variables (W_x 's) as instrumental

variables^{12, 52}. In the second stage, the adjusted school-catchment measure of binge drinking was regressed on the environment-based factors; on interactions involving structural risk factors and protective factors; and on the spatial lag term (*Wy*). The not-significant effect of the spatial lag term resulting from the final spatial lag regression model indicates that students' binge drinking was a function of individual-level risk and protective factors as well as structural and social-relationship characteristics associated with the focal catchment only. Readers may request the results of the spatial regression analysis, which are not shown here.

DISCUSSION

The results of our study clearly indicate that both environment-based factors and individual-level risk and protective factors are important in explaining student binge drinking in Alabama. Several major findings deserve further discussion. Our study results show that encouragement of student prosocial behavior by community and school protected our sample against student binge drinking (see Table 3). Our structural risk factors, including alcohol-outlet density, community instability, and population disadvantages, were found to have minimal direct effects increasing binge drinking. Indeed, inconsistent with previous studies, some of the factors showed an unexpected protective impact against binge drinking^{10, 28}. These unexpected findings may reflect our use of unique contextual units of analysis or the composition of a population unique to Alabama.

The use of school-catchments as our contextual units was appropriate to our study, since it aimed to understand binge drinking by students enrolled in Alabama public schools. Students attending the same school and enrolled in the same grades find frequent opportunity to congregate at school, to interact while riding school buses, and to gather in the community they jointly reside in. We note, however, that the school-catchment acting as unit of analysis and simultaneously as specific community boundary has not been used by earlier researchers investigating community-contextual influences on substance use by adolescents or adults³³. Our finding that structural risk factors (population disadvantages, community instability, etc.) are likeliest to foster student binge drinking in school-catchments exhibiting relatively more community encouragement of student prosocial behavior well deserves further study in the future.

Unexpected effects on student binge drinking we observed for our structural risk factors may reflect, to some extent, the South's unique population composition. One earlier study that looked at county-level structural disadvantages to understand individual-level student substance use found additional county disadvantages to be associated with diminished substance use¹⁴. The authors attributed the unexpected result to a lack of measures of the social relationships within the various communities making up the counties. In the present study, looking at protective role of community and protective role of school helped us capture community social relationships likely to be associated with decreased deviance: relationships that may be the mechanisms linking structural risks to student binge drinking in a school-catchment¹². The structural risk factors we measured in this study, rather than determining student binge drinking, actually moderated and constrained the protective effects of the 2 community social relationships; this is shown in the significant interaction effects involving population disadvantages and protective role of community ($b = .004, p < .05$); those involving community instability and protective role of community ($b = .005, p < .05$); and those involving community instability and protective role of school ($b = -.005, p < .01$). It is a finding that underlines the importance of guardianship and collective efficacy, since strong community and school protective roles like those found in this study both exemplify guardianship and collective efficacy and provide social mechanisms joining student binge drinking to social disadvantages (e.g., alcohol-outlet density, population disadvantages)^{33, 41}.

Using school-catchments as the contextual units of analysis, we discovered that a community's residents and a school's personnel are alike capable of providing protection against student binge drinking by encouraging youths' involvement in prosocial activities. This protective capacity of the residents and personnel was often strong enough to counteract negative effects of a school-catchment's social and economic disadvantages, even when these were numerous.

We find especially interesting the facilitating role that community instability played here, via protective role of school, in the reduction of student binge drinking (see Table 3, Model III results). As we assessed the community instability index we developed for this study, we realized that several variables from our index seemed potential channels for individual-level upward mobility: percentage of population 25 years and older having a college degree; percentage of population 25 years and older having a high school diploma; percentage of population that is urban. In Alabama, such a relatively large percentage of the population is rural-based that community stability may connote social *disadvantages* instead of (as in prior studies with other samples) social advantages⁴⁰. This may be responsible for the unexpected effects on student binge drinking that we identified.

It is important that our study observed not-significant spatial effects on student binge drinking following control of the confounding individual-level risk/protective factors, structural risk factors, and community/school protective factors. We were surprised to measure only a minor direct effect of alcohol-outlet density on student binge drinking. The significant interaction effect involving alcohol-outlet density and grade level (Model IV, $b = .003, p < .05$), however, signaled that the relationship between increased binge drinking and higher grade level was more pronounced for catchments having denser alcohol outlets. Density's effects on increased student binge drinking were, here, largely channeled by students' grade level. Thus older students residing in a catchment with denser alcohol outlets were likelier than other students to binge drink with relative frequency. This finding indicates that developing immediate-environment-based social-relationship factors can adequately contextualize and reduce student binge drinking, indicating that location is indeed pertinent to the study of student binge drinking. Geographic location and spatial analysis thus deserve more prominence in social science research on substance use.

Adolescent drinking is a prominent public health issue in the United States, its consequences costly and sometimes fatal¹. Results from the present study contribute to the literature in three ways. First, the study contextualized associations of important individual-level risk and protective factors with students' binge-drinking behavior in their relevant school-catchments. Second, our study took into account possible spillover effects plausibly responsible for similar levels of student binge drinking found across adjacent school-catchments. Third, our study examined interaction effects involving structural disadvantages (population disadvantages, community instability, and alcohol-outlet density) and protective factors (protective role of school and protective role of community) in order to delineate how such protective factors help explain individual-level student binge drinking, if they do.

Two limitations should be mentioned. First, our study focused on only one, unusually rural state, Alabama, 44.6% of whose population lives outside urban and suburban areas. We must, then, be cautious about generalizing our findings to students outside Alabama. Second, we could not obtain direct measures of the two protective factors for the school-catchments, although we did access census data to provide our study with the 3 structural disadvantage factors for analysis.

These two limitations notwithstanding, our study results do illustrate the importance of educating policy makers and the public about geographic location's important role in public

health issues. The study results imply, furthermore, that protective factors including encouragement generated from the community and the school can be consciously created, aiming to minimize student binge drinking across school-catchment areas.

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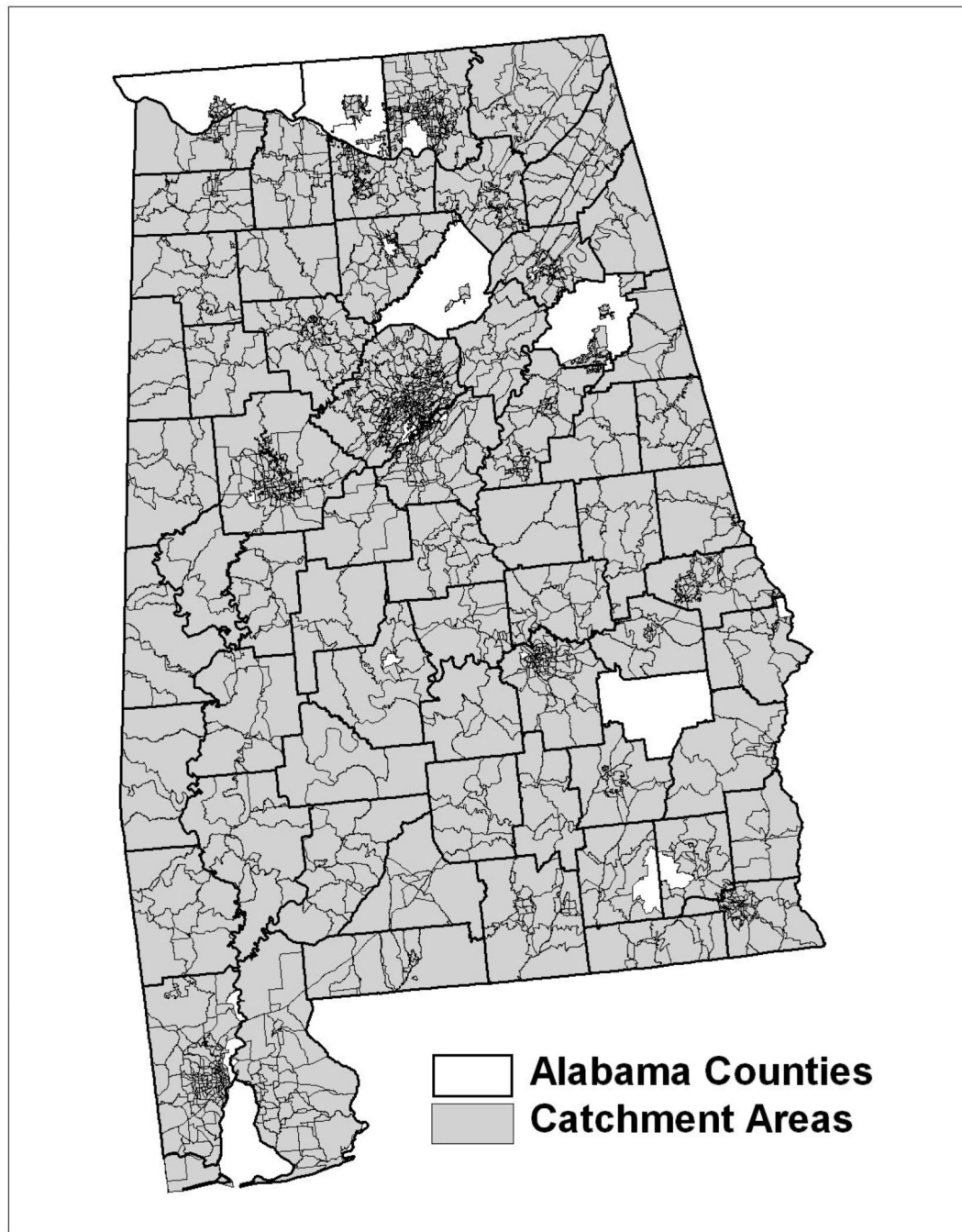


Fig 1. Catchment Areas in Alabama for all grade levels. Blank areas indicate county or school districts not included in study or water areas not included within any school catchment.

Table 1
Means, Standard Deviations, and Correlations of All Individual-Level Variables (N=78,138)

	Correlations							Mean	S.D.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
LnBinge (1)	1							0.132	0.360
Grade (2)	.180	1						3.813	1.929
Male (3)	.094	-.008	1					0.456	0.498
Religion (4)	-.127	-.008	-.035	1				3.164	1.050
Protective Role of Family (5)	-.142	-.162	.034	.161	1			0.061	2.416
Peer Drug Use (6)	.462	.373	.060	-.168	-.248	1		3.703	4.152
Protective Role of Self (7)	-.371	-.190	-.169	.259	.349	-.484	1	0.064	1.602

Note: All correlations significant at .05 level.

Table 2
Means, Standard Deviations, and Correlations of Mean Ln Binge Drinking and All Environment-Based Variables

(N=566 School-Catchments)	(1)	(2)	(3)	(4)	(5)	Mean	S.D.
	Mean Ln Binge Drinking (1)	1					0.118
Community Protective Role (2)	-.565**	1				0.130	0.359
School Protective Role (3)	-.290**	.468**	1			0.155	0.445
Instability (4)	-.007	-.198**	-.122**	1		-0.045	3.817
Population Disadvantages (5)	-.028	-.190**	-.052**	-.049	1	-0.324	4.683
Alcohol-Outlet Density (6)	-.047	-.198**	-.047**	.515**	.144**	0.052	2.962

* p < .05

** p < .01

Table 3
 Estimated Effects of Individual-Level and Environment-Based Factors on Ln (Binge Drinking)

Fixed Effect	Model I	Model II	Model III	Model IV
Mean Frequency of Binge Drinking				
Intercept	0.117 **	0.116 **	0.116 **	0.116 **
Community Protective Role		-0.036 **	-0.036 **	-0.060 **
School Protective Role		-0.039 **	-0.039 **	-0.070 **
Population Disadvantages		-0.001	-0.001 *	-0.002 *
Instability		0.000	-0.001 *	-0.003 **
Alcohol-Outlet Density		-0.002 *	0.000	0.000
Disadvantages *Community			0.004 *	0.004 *
Instability *Community			0.005 *	0.004 *
Disadvantages *School			0.001	0.001
Instability *School			-0.005 **	-0.004 **
Density *Community			0.004	0.005
Density *School			0.002	0.003
GRADE				
Intercept	0.005 **	0.006 **	0.006 **	0.006 **
School Protective Role				-0.010 **
Population Disadvantages				0.001 **
Alcohol-Outlet Density				0.003 *
MALE				
Intercept	0.023 **	0.024 **	0.024 **	0.022 **
School Protective Role				-0.027 **
RELIGION				
Intercept	-0.006 **	-0.006 **	-0.006 **	-0.006 **
Instability				0.001 **
FAMILY				
Intercept	0.002 **	0.002 **	0.002 **	0.002 **

Fixed Effect	Model I		Model II		Model III		Model IV	
	Variance	chi-Square	Variance	chi-Square	Variance	chi-Square	Variance	chi-Square
PEER DRUG USE								
Intercept	0.029	**	0.029	**	0.029	**	0.029	**
Population Disadvantages							0.000	*
SELF								
Intercept	-0.039	**	-0.039	**	-0.040	**	-0.039	**
Community Protective Role							0.019	**
School Protective Role							0.021	**
Population Disadvantages							0.001	**
Instability							0.001	**
Random Effect	Variance	chi-Square	Variance	chi-Square	Variance	chi-Square	Variance	chi-Square
Intercept	0.0054	3458.37	0.0039	2628.49	0.0038	2540.72	0.0034	2264.49
GRADE	0.0001	516.24	0.0001	515.10	0.0001	514.83	0.0001	483.60
MALE	0.0006	501.62	0.0006	500.66	0.0006	500.52	0.0005	480.24
RELIGION	0.0002	545.22	0.0002	545.19	0.0002	545.22	0.0002	532.59
FAMILY	0.0000	498.62	0.0000	497.66	0.0000	497.59	0.0000	496.44
PEER DRUG USE	0.0001	897.95	0.0001	887.83	0.0001	887.26	0.0001	874.86
SELF	0.0006	931.80	0.0006	920.88	0.0006	919.65	0.0004	772.25
Level-1 Effect, rij	0.0963		0.0963		0.0963		0.0962	

All variance components were found to be significant at $p < .01$.

* $p < .05$

** $p < .01$