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Ecological Associations of Alcohol Outlets with Underage and Young Adult Injuries

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Abstract

Objective—This paper argues that associations between rates of three specific problems related to alcohol (i.e., accidents, traffic crashes, and assaults) should be differentially related to densities of off-premise outlets among underage youth and young adults based upon age related-patterns of alcohol outlet use.

Methods—Zip code-level population models assessed local and distal effects of alcohol outlets upon rates of hospital discharges for these outcomes.

Results—Densities of off-premise alcohol outlets were significantly related to injuries from accidents, assaults, and traffic crashes for both underage youth and young adults. Densities of bars were associated with more assaults and densities of restaurants were associated with more traffic crash injuries for young adults.

Conclusions—The distribution of alcohol-related injuries relative to alcohol outlets reflect patterns of alcohol outlet use.

INTRODUCTION

Empirical studies of the relationships between alcohol outlets, alcohol use and related problems among adults have demonstrated that greater outlet densities are related to drinking and several alcohol-related problems (e.g., motor vehicle crashes, pedestrian injuries, and violence). For example, with regard to overall consumption, Gruenewald et al. (1993) found that a 10% decrease in the density of alcohol outlets would reduce consumption of spirits by from 1% to 3% and consumption of wine by 4%. More recently, however, and with good reason, attention has shifted from effects on overall consumption to the broader issue of alcohol-related problems since numerous cross-sectional studies have examined the relationship between outlet densities and homicides and assaults (Gorman et al., 1998, 2001; Gruenewald et al., 2006; Lipton & Gruenewald, 2002; Parker & Rebhun, 1995; Roncek & Maier, 1991; Scribner et al., 1995; Speer et al., 1998; Stevenson et al.,

1999; Zhu et al., 2004), child maltreatment (Freisthler et al., 2004), pedestrian injury (LaScala et al., 2001), youth drinking and driving (Treno et al., 2003), and alcohol-related automobile crashes (Gruenewald et al., 1996, 2002; Treno et al., 2007). The existence of a link between outlets and problem outcomes appears, if theoretically unexplained, irrefutable. Moreover, it would appear as if certain types of outlets are associated with different types of problem outcomes. Outcomes related to assaults generally appear to be associated with bar and off-premise outlet densities while drinking and driving generally appears associated with restaurant density. What is not known is how different age groups are impacted by different forms of availability.

The notion that different age groups are impacted by different forms of availability emerges from a merging of two separate but related approaches. The first, the routine activity approach would suggest that differentially situated individuals “use” different types of outlets in a process of conducting their various “routine activities” with differential impact. Thus younger and single persons would likely tend to use on-premise establishments while older persons would tend to use off-premise outlets, a pattern supported by empirical observation. These differential use patterns are affected by the various “opportunities and constraints” to consume alcohol which constitute the drinking environment. This approach has found empirical support also in recent empirical work (Treno et al., 2008) focusing on differential access among youth. When combined these approaches suggest that routine activities emerge in response to the constraints and opportunities in the alcohol environment whether they be physical, economic, social or legal.

Theoretically, access to alcohol by youth may occur through a number of routes including (a) direct purchase of alcohol themselves, (b) arranging purchase through others, and (c) obtaining alcohol by other social means (e.g., from parents, at parties). However, because of various “constraints” in the youth environment most access is through social sources. Secondly, the most common means for direct purchase of alcohol by underage youth is through off-premise outlets such as convenience and grocery stores; purchase from on-premise outlets, such as bars and restaurants are relatively rare (Harrison et al., 2000; Wagenaar et al., 1996). Because the geographic distribution of stores, restaurants and bars varies a good deal, one might consider whether rates of underage sales and resulting problems may be different across neighborhoods or be differently related to specific problem outcomes, and whether these patterns might differ from those characterizing adult sales and resulting problems.

THE CURRENT STUDY

Based upon the reasoning stated above two hypotheses are tested in the paper. The first is that densities of off-premise alcohol outlets will be significantly related to injuries from accidents, assaults, and traffic crashes for both underage youth (18–20 years) and young adults (21–29 years). This is because such outlets are a ready source of alcohol to use, because youth may be the secondary victims of other drinking, and because overall off-premise availability may create increased opportunities for obtaining alcohol. The second hypothesis is that densities of bars will be associated with more assaults, and densities of restaurants will only be associated with more traffic crash injuries for of-age young adults, but not underage youth. This is because youth typically are not affected by such availability.

To examine these two hypotheses this paper reports the results of an investigation into the association between on- and off-premise outlets and three problem outcomes (accidents, traffic injuries, and assaults) among underage youth (18–20 years of age) and of-age young adults (21–29 years of age) measured using hospital discharge data. These data represent accidents or injuries that are serious enough to require an overnight stay in a hospital; this is

generally a sign of greater problem severity (see Lipton & Gruenewald, 2002). In the absence of prior general studies of this kind, the current study considers whether there is evidence linking alcohol outlet densities to these problems at the population level. To address these research questions the current study applied population models that distinguished the effects of population from place characteristics (including off- and on-premise outlets) on problem outcomes, while accounting for the spatial structure of population data. Additionally, the current study sought to distinguish the impacts of local population and place characteristics on local problems from effects related to characteristics of populations or places nearby. (For a complete discussion of the use of spatial lagged effects to assess population interactions across geographic areas, see Lipton & Gruenewald, 2002 and Gruenewald et al., 2006).

METHODS

Non-public hospital discharge data including residential zip code and patient age for all patients discharged during 2000 were obtained from California's Office of Statewide Health Planning and Development. These data include ICD-9 E Codes from which the dependent measures were created. Counts of injured patients by 1646 California zip codes and two age groups (underage youth between the ages of 18 and 20 and of-age young adults aged 21–29 years) were created for three injury outcomes: (1) accidental injuries excluding motor vehicle accidents, medical misadventure, adverse reactions to medications, (2) traffic injuries, and (3) assault injuries. The choice to use hospital discharge data limits this dataset to patients with severe injuries (e.g., this dataset does not include patients treated only in emergency rooms and then released, nor does it contain patients treated in outpatient facilities) reducing possible bias due to insurance coverage (e.g., a person with a serious assault injury is usually one with concussion, multiple broken bones or penetrating injuries and would probably be treated in a hospital even if he/she did not have insurance coverage). Ninety-nine percent (99%) of the injury records for California residents were successfully mapped to zip codes. The count of these injuries in each area was used as the outcome variable.

Data for the independent measures related to population and place characteristics were obtained from three sources: 2000 Census (US Census Bureau 2001, GeoLytics Inc., 2004), California Alcohol Beverage Control and the U.S. Department of Commerce, Economics and Statistics Administration. Population characteristics were obtained from the 2000 Census and include variables used to calculate the percents for unemployment, in poverty, female heads of households with children, African American, Hispanic (excluding black Hispanics), foreign born, owner occupied housing (of all housing units), households moved in the past 5 years, recent (past year) movement, married, high school graduates, college graduates, youth 15 to 29 years, income greater than \$75,000. Based upon previous work on the effects of income inequality by Morenoff et al. (2001), an index of concentrated extremes (ICE) was also constructed (difference in households earning more than \$75,000 vs. less than \$20,000 divided by total number of households). A value of 1.0 on this measure reflects concentrated wealth and a value of –1.0 reflects concentrated poverty.

In order to reduce the number of data elements in the current study to a more useable number, factor analyses of population demographic characteristics were conducted. The first four principal components of the covariance matrix of these variables were obtained using oblique factor rotations; these were then used to derive four scales that characterized differences in population characteristics of residents across California zip codes. These four principal oblique factors described 91.0% of the variance in measures between places in California. Standardized scale scores on the factors represented (1) Unstable Poor Minority Urban Areas (48.7%, places with a large proportion of African American and Hispanic

minorities, low home ownership and high turnover in housing, high unemployment, and concentrated poverty), (2) Stable Wealthy Majority Suburban Areas (15.3%, places with large proportions owner occupied housing and low housing turnover, fewer minorities, concentrated wealth and greater income inequality), (3) Middle Income Immigrant Hispanic Areas (20.6%, places with moderate incomes, large immigrant and Hispanic populations, and low home ownership), and (4) Middle Income Majority Rural Areas (8.3%, places with moderate incomes, fewer minorities, predominantly married households, with greater home ownership but high turnover in housing.). These four scale scores have been used in prior analyses to represent population characteristics and linked to various problem indicators (Gruenewald et al., 2006).

Data on the locations of alcohol outlets were obtained from California Alcohol Beverage Control. Numbers of alcohol outlets by zip code were tabulated for off-premise establishments, restaurants, and bars/pubs. Only establishments with active licensure at the beginning of January 2000 were used in this study. Data were geocoded to zip code of outlet location with geocoding rates exceeding 98%.

County business pattern data for 1999 were obtained from the U.S. Department of Commerce, Economics and Statistics Administration and include an assessment of numbers of retail establishments within zip codes by type, using North American Industry Classification (NAIC) system codes. Numbers of non-alcohol retail establishments were tabulated for non-alcohol food retail (e.g., snack food distributors), non-alcohol other retail (e.g., gas stations, clothing and hobby stores), and other non-alcohol services and accommodations (e.g., motels). Geocoding rates exceeded 99%.

Densities of alcohol outlets, retail establishments and vacant houses were computed as rates per roadway mile rather than per square mile of area. The denomination by roadway mile is more appropriate especially in rural zip codes, where populated corridors are typically separated by large tracts supporting little human activity. Roads are the principal means by which persons come into contact with alcohol and other retail establishments, so this form of denomination reflects the ease of access to these businesses. Rates per roadway mile similarly reflect residents' level of interaction with vacant housing.

ECOLOGICAL MODEL

In order to address our research questions, we needed to develop an ecological model that managed several methodological concerns. These included methods to account for the contribution of population and place characteristics to problem outcomes, correlations of measures across geographic areas, and heteroskedasticity related to population size.

The first issue was addressed by developing an ecologically-based analysis model that could be used to test the contribution of both population and place characteristics of both local and nearby populations on injury outcomes. The effects of population density were characterized in two ways. First, because population size, in and of itself, may be productive of more problems, a direct effect for population size was included. Second, because some outcomes could be the result of population interactions over more or less dense spatial areas, a measure of the packing of populations into geographic areas was also included (population in thousands per mile of roadway). It was presumed that this effect would be generally positive, reflecting greater contact between persons and places within highly urbanized neighborhoods. Local population characteristics were represented by the derived scales for unstable poverty, stable wealth, unstable immigrant, and rural majority populations. These variables represented the impacts of local populations with these characteristics upon local rates of problem outcomes. Lagged population characteristics were represented by the same four scales measured in zip codes immediately adjacent to local areas. These variables

represented the impacts of nearby populations with these characteristics upon problems experienced by local populations. Local place characteristics were represented by densities per roadway mile of each of the place variables including numbers of alcohol outlets, vacant housing and other retail stores. Effects related to these measures were presumed to be related to contacts in and around these places. Lagged place characteristics represented measures of the densities of each place variable in adjacent areas, and were presumed to represent the impacts of adjacent place characteristics on local problems. Together these measures imply a spatial dynamic that relates population interactions to the incidence of problem outcomes among underage youth and of-age young adults (Smith et al., 2000; Rice & Smith, 2003). Rao's likelihood ratio chi-square tests were used to assess the separate contribution of each of these components of the model (G^2 ; Fienberg, 1980).

The remaining two analytical issues were addressed through the use of zero inflated negative binomial models and the assessment of spatial autocorrelation (i.e. level of correlation across zip codes) of the residuals from these models. Negative binomial models provide a flexible approach to modeling count data that allows for over-dispersion relative to the Poisson distribution. Zero inflated negative binomial models, performed using LIMDEP 9.0 software, enable direct modeling of count data under circumstances in which an unobserved process produces an excess of zeros relative to a negative binomial distribution (Greene, 2007). Zero inflation may occur for many reasons, including inaccurate case ascertainment or other sources of unobserved incidence of cases.

Spatial autocorrelation, the tendency for neighboring places to have similar characteristics, may represent a failure of unit independence among observations and can potentially bias hypothesis tests for model estimates. Spatial autocorrelation was estimated using Moran's I statistic (Moran, 1950; calculated using Spatial Statistical System, S3, Ponicki & Gruenewald, 2003). This statistic can range from -1 (perfect spatial dispersion, as in a checkerboard pattern) to 1 (maximum correlation between neighbors), with 0 indicating a random spatial pattern. The raw injury measures exhibited fairly strong spatial autocorrelation (Moran I ranging from 0.27 to 0.42). As shown below, this spatial autocorrelation of the outcome measures was almost entirely explained by covariates, with Moran I being small and non-significant for all model residuals. Each unit of analysis (zip code) was weighted by population size of each specific age group to control for heteroskedasticity related to population size found in small area analyses (Greene, 2003).

In contrast to linear regression analyses, the coefficients of the nonlinear models used here cannot be directly interpreted as the expected change in the outcome measure associated with a one-unit change in an exogenous variable. The effect of a given outlet-density indicator upon each outcome measure is thus presented below as an elasticity, defined as the percent change in the outcome count associated with a one-percent change in a density measure. These elasticities were based on a marginal-effects transformation of the regression coefficients computed under the assumption that all variables are at their sample means (Greene, 2007).

RESULTS

Table 1 presents descriptive statistics for all variables used in the analyses. Outcome measures are presented separately for each age group (underage youth 18 to 20, and of-age adults 20–29). Local and lagged population densities are also provided separately for these two age groups.

Table 2 presents block tests (Rao's likelihood ratio chi-square) assessing the group-wise contribution of the local and lagged population and place characteristics to the overall fit of

separate models for 18–20 and 21–29 year olds for all three outcome measures (accident, assault and traffic crash injuries). Each test indicates the improvement in fit of the full model compared to a model excluding the specified block of variables. With regard to accidents and assaults all but the lagged place characteristics were significantly related to numbers of observed cases for both 18–20 and 21–29 year olds. With regard to traffic crashes lagged place characteristics were not significant among 18–20 year olds, while lagged population characteristics were not significant among 21–29 year olds. Overall these analyses show that measures of population and place characteristics within local and lagged areas are essential components of population models of these problem outcomes.

Tables 3 and 4 showed the detailed results from the zero inflated negative binomial models for 18–20 and 21–29 year olds, respectively. As a general observation, across all six models, statistical tests for over-dispersion (relative to a Poisson model) and zero inflation (relative to an uninflated negative binomial alternative) were significant. All assessments of spatial autocorrelation were not significant. The over-dispersion and zero inflation parameters, and the results of each test for spatial autocorrelation (Moran coefficient estimated using a row stochastic binary adjacency matrix), are shown at the bottom of both tables. The nominal significance levels of statistical tests for variables within each block of measures should be viewed with some caution as some Type I errors in analysis are to be expected. However, the block tests provide some protection against these errors in analysis.

Injuries among 18–20 year olds

Verifying the basic assumptions of the population model, across all three injury outcomes, population size in local and lagged areas was directly related to observed numbers of hospitalizations. However, only local population densities were significantly, and negatively, related to numbers of assault and traffic injuries. These significant negative coefficients indicate some suppression of injury counts in densely populated urban areas.

All three types of injury were more likely to be observed among unstable poor and stable wealthy populations. More accident injuries were specifically related to larger rural majority populations. More assault injuries were specifically related to larger immigrant Hispanic populations. Among the lagged population measures all three types of injuries were less likely to be observed in areas adjacent to unstable poor populations. Fewer accident injuries were specifically related to areas adjacent to immigrant Hispanic populations. Fewer assault injuries were specifically related to areas adjacent to rural majority populations.

Considering local place characteristics only densities of off-premise outlets were positively related to numbers of accident, assault and traffic injuries. Densities of non-alcohol services were negatively related to accident and assault injuries. Densities of vacant housing were positively related to accident and assault injuries. As noted in Table 2, as a group lagged place characteristics were not related to numbers of any injuries.

Injuries among 21–29 year olds

In this age group population sizes in local and lagged areas were significantly related to numbers of accident, assault and traffic injuries in local populations. Local population densities were consistently negatively related to numbers of injuries. These aspects of the models were very similar between the two age groups.

All three types of injury outcomes were more likely to be observed among unstable poor populations. More assault injuries were also observed among stable wealthy populations. Fewer accident and traffic injuries were observed among immigrant Hispanic populations. Fewer assault and traffic injuries were observed among rural majority populations. Among these 21–29 year old young adults, effects related to lagged population characteristics were

sparse. Fewer accident injuries were observed in areas adjacent to unstable poor populations, and fewer assault injuries were observed in areas adjacent to rural majority populations.

Considering local place characteristics, densities of off-premise outlets were positively related to numbers of accident, assault and traffic injuries. Densities of bars or pubs were related to greater numbers of assaults. Densities of restaurants were related to greater numbers of traffic injuries. Densities of non-alcohol services were negatively related to assault and traffic injuries. Densities of vacant housing were positively related to accident and assault injuries. As noted in Table 2 lagged place characteristics were not related to numbers of accident and assault injuries. Areas adjacent to places with greater densities of off-premise outlets and non-alcohol food retailers had lower numbers of traffic injuries. Areas adjacent to places with greater densities of non-alcohol retail stores had greater numbers of traffic injuries.

Table 5 presented elasticity estimates computed from the significant alcohol outlet effects provided in Tables 3 and 4. These elasticities indicate that a 10% increase in off-premise outlets within a zip code was associated with an increase in the six problem measures ranging from 0.9% to 1.6%. A 10% rise in local restaurants or bars was associated with increases of less than one percent in traffic or assault injuries, respectively, among the older age group. A 10% rise in off-premise outlets in neighboring communities was associated with a 1.7% increase in accident injuries in the younger group and a 1.5% decrease in traffic accidents among the older group.

DISCUSSION

The results of this study support the stated hypotheses that there appear to be unique ecological relationships between densities of off-premise alcohol outlets and rates of accident, assault and traffic injury cases among young adults. Across all of the tested models densities of off-premise outlets were consistently related to numbers of problem outcomes that result in at least one night of hospitalization. These effects were observed using population models appropriate to these data (zero inflated negative binomials), and with substantive controls for (a) population sizes and densities, (b) local and lagged population and place characteristics, and (c) characteristics of populations and places potentially related to these injury outcomes. In this regard one of the substantive risks to the interpretation of effects related to alcohol outlets is that outlets may indicate places where unique configurations of population and place characteristics lead to greater rates of problem outcomes. The primary reason for the complexity of the modeling effort presented here was to reduce these potentially confounding effects to a minimum while testing for off-premise effects on injury outcomes among young people.

As suggested in the introduction, the cross-sectional relationships between on-premise outlet densities and problems for underage versus of-age problems should be characteristically different and our results support this line of reasoning. Indeed, while the densities of restaurants, and bars or pubs were unrelated to accident, assault and traffic injury cases among underage youth, assault injuries among youth 21–29 years of age were specifically associated with densities of bars and pubs. In addition traffic injuries among this older group of young adults were specifically associated with densities of restaurants, but not bars or pubs. This latter observation is particularly pertinent as densities of restaurants, not bars and pubs, have been associated with rates of drinking and driving (Gruenewald et al., 2002) and crashing (Gruenewald et al., 1996) in previous individual and ecological studies in California. Thus the results of the current analyses reflect much of what is currently understood about the relationships of injury outcomes and alcohol outlets at the population level.

The off-premise effects observed in this study were not confined to underage youth, although Table 5 indicates that off-premise outlet density elasticities were somewhat larger for this younger group. Of-age youth, 21–29 year olds, also exhibited a positive association between problem outcomes and densities of off-premise outlets. This indicates that the mechanism that supports the association is not restricted in effect to underage youth, but rather is broader in scope, affecting all young adults. Alternatively, there may be more than one explanatory mechanism operating, perhaps a different one for different age groupings with similar results. Thus, the fact that underage youth may use off-premise outlets to access alcohol (either directly or indirectly via legal age purchasers) may or may not be the pertinent issue with regard to these relationships, while yet another mechanism altogether may be operative for of-age purchasers. Interestingly, because there is little difference in the ages and even many of the activities of underage and of-age young adults, other social mechanisms may explain these findings. Underage youth may participate in social networks that include of-age youth and provide support not only for purchase of alcohol, but also provide reinforcements for specific drinking practices, such as drinking and driving, and drinking in the home. In this regard, it is pertinent to note that of-age young adults in California have been shown to drink more frequently at home, rendering their use of off-premise outlets more likely (Gruenewald et al., 2000).

The fact is we do not know what social and/or structural mechanisms operate to support the appearance of significant associations between densities of off-premise outlets and injuries among of-age and underage young adults. Two prominent positions might be taken on this issue. The first argues that access to alcohol through off-premise establishments enables both greater levels of drinking as well as exposure to other harms (e.g., violence associated with illegal drug dealings); although the focus of the first argument has been upon underage youth, clearly all young adults, of-age or underage, may be affected by these additional exposures. The second position maintains that greater densities of alcohol outlets reflect greater levels of neighborhood disorganization that are associated with these injury outcomes. The focus of the second position was directly addressed in the current study. We included a sophisticated array of measures of neighborhood disorganization representing population and place characteristics of local and lagged spatial areas, within the framework of a comprehensive ecological model, and we found that the effects of off-premise outlets persist. It would seem that densities of off-premise outlets are of independent significance to the problem of understanding injury outcomes among young adults.

With regard to the other findings from the study, all young adult populations living in areas with high levels of residential instability and poverty are also at greater risk for accident, assault, and traffic crash injuries. One surprising pattern in these results is that all injury measures exhibit a significant positive association with local unstable poverty, but four of six injury measures also show a significant negative relationship with poverty in adjacent zip codes. The positive relationship between density of vacant housing and accident and assault injuries suggests that these measures might indicate low place management in these areas and allow other risky behaviors to develop and perpetuate unchecked. The positive relationship between lagged retail density for food and other retail (e.g., clothing stores) and injuries from traffic crashes quite reasonably suggests that people move in and out of local areas during the normal course of their daily life, and in doing so, become more vulnerable to traffic crash injuries.

Finally, significant findings related to other lagged population characteristics provide support for a spatial dynamic with respect to the effects of local and distal populations and injury outcomes. For example, the observation that greater population densities in surrounding areas were significantly related to injury rates in local areas, leads to two very important questions about the measurement and meaning of ecological variables in studies

of this kind. Are these population effects related to local as well as distal populations? In this case, greater rates of accident, assault and traffic injuries may be related to the greater level of human traffic that arises in dense urban areas (e.g., greater roadway traffic volume). Or are these population effects themselves markers for other unmeasured variables relevant to these models? In this case, the observed lagged population variables may be related to other unmeasured characteristics of local populations, such as their perceptions of crime risk (Sampson & Raudenbush, 2004). By including variables related to non-alcohol retail density as well as lagged measures of both population and place characteristics, this study was able to assess at least partially the unique relationships of alcohol outlets to injury rates among both underage and of-age young adults.

Limitations

This study begins to examine the risks associated with different types of alcohol outlet densities among various population sub-groups, but it does not allow us to ascertain the mechanisms by which these problems occur. Is it through alcohol access and frequency of use (Gruenewald et al., 2002)? Or is the presence of alcohol outlets related to other, as yet unmeasured structural processes occurring in these areas? Studies that incorporate characteristics of individual behaviors, such as drinking patterns, social interactions around drinking and related behaviors and modes of alcohol access, need be examined in conjunction with ecological information about the environment to begin to answer these questions. While much of this discussion has addressed the restricted degree to which we understand the mechanisms that may relate the availability of alcohol through alcohol outlets to rates of problems among young people, it is important to recognize that both the geographic units under study and the cross-sectional design of this ecological study may partially explain the findings obtained here. Zip codes are rather large geographic units and, although considerable controls are provided in the current study to protect against confounding, estimates of relationships between outlets and problems may be biased by systematic variations in the sizes and shapes of these units related to population and place characteristics (the modifiable area unit problem, Openshaw, 1984). These biases are best removed through the use of homogeneously defined units, an impossibility in this case, or through the study of changes in population and place characteristics within units over time (geographically based longitudinal designs). These types of longitudinal designs have proven invaluable in the assessment of violence related to changing numbers of bars within areas over time (Gruenewald & Remer, 2006). We expect that such work can make significant contributions to understanding the relationships between outlets and other young adult problem outcomes.

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Table 1Descriptive Statistics ($n = 1,646$)

Variable	Mean	SD
Outcome measures		
Accidents, age 18 to 20	2.0529	2.7755
Accidents, age 21 to 29	5.8384	7.4211
Assaults, age 18 to 20	1.1750	2.5814
Assaults, age 21 to 29	2.4168	4.7776
Traffic, age 18 to 20	1.8074	2.5463
Traffic, age 21 to 29	3.9241	4.9003
Population and density (1,000s)		
Population, age 18 to 20	0.8928	1.1201
Population, age 21 to 29	2.6826	3.1093
Population per road mile, age 18 to 20	0.0158	0.1334
Population per road mile, age 21 to 29	0.0312	0.0561
Lagged population and density (1,000s)		
Population, age 18 to 20	1.0062	0.8215
Population, age 21 to 29	2.9930	2.3258
Population per road mile, age 18 to 20	0.0099	0.0206
Population per road mile, age 21 to 29	0.0292	0.0370
Local population factor scores		
Unstable poor	0.0008	0.0081
Stable wealthy	0.0008	0.0089
Immigrant Hispanic	-0.0041	0.0088
Rural majority	-0.0005	0.0082
Lagged population factor scores		
Unstable poor	0.0007	0.0066
Stable wealthy	0.0010	0.0052
Immigrant Hispanic	-0.0042	0.0074
Rural majority	-0.0002	0.0061
Local place density per road mile		
Off-premise outlets	0.1920	0.5263
Restaurants	0.3189	1.9042
Bars or pubs	0.0605	0.4540
Nonalcohol other retail	0.4834	2.8865
Nonalcohol food retail	0.0302	0.1552
Nonalcohol services	0.1124	0.4529
Vacant housing	5.4097	17.2616
Lagged place density per road mile		
Off-premise outlets	0.1750	0.2516
Restaurants	0.2634	0.7039
Bars or pubs	0.0482	0.1263

Variable	Mean	SD
Nonalcohol other retail	0.4326	1.2320
Nonalcohol food retail	0.0277	0.0728
Nonalcohol services	0.1031	0.2703
Vacant housing	4.3598	6.1496

Table 2

Rao's Likelihood Ratio Chi-Square Tests of Model Fit for Blocks of Variables Compared With Full Model ($n = 1,646$)

	df	Accidents			Assaults			Traffic crash		
		Δ	G^2	P	Δ	G^2	P	Δ	G^2	P
18- to 20-year-olds										
Local population and density	2	472.92	<0.001		430.37	<0.001		445.38	<0.001	
Lagged population and density	2	34.67	<0.001		61.09	<0.001		62.14	<0.001	
Local population characteristics	4	41.90	<0.001		168.98	<0.001		38.83	<0.001	
Lagged population characteristics	4	32.99	<0.001		39.32	<0.001		23.00	<0.001	
Local place densities	7	41.27	<0.001		30.85	<0.001		18.89	0.009	
Lagged place densities	7	12.28			13.68			3.58		
21- to 29-year-olds										
Local population and density	2	1,048.15	<0.001		657.46	<0.001		850.35	<0.001	
Lagged population and density	2	44.92	<0.001		31.63	<0.001		78.98	<0.001	
Local population characteristics	4	56.59	<0.001		146.63	<0.001		30.69	<0.001	
Lagged population characteristics	4	13.25	0.010		10.51	0.033		7.16		
Local place densities	7	33.01	<0.001		40.64	<0.001		26.27	<0.001	
Lagged place densities	7	6.42			4.91			23.66	0.001	

Note: p -values are shown only for block tests that are significant at the 0.05 level. Each test indicates the improvement in fit for the full model relative to a model that excludes the specified block of exogenous variables.

Table 3

Zero Inflated Negative Binomial Models for Injuries due to Accidents, Assaults, and Traffic Crashes Among Youth Aged 18 to 20 ($n = 1,646$)

Variable	Accident injuries			Assault injuries			Traffic injuries		
	<i>b</i>	SE	<i>P</i>	<i>b</i>	SE	<i>P</i>	<i>b</i>	SE	<i>P</i>
Constant	0.256	0.062	<0.001	-0.144	0.064	0.025	0.215	0.068	0.002
Population and density									
Population ($\times 1,000$)	0.285	0.010	<0.001	0.321	0.014	<0.001	0.335	0.011	<0.001
Population per mile ($\times 1,000$)	-0.336	0.213		-18.336	2.024	<0.001	-9.553	1.023	<0.001
Lagged population and density									
Population ($\times 1,000$)	0.173	0.030	<0.001	0.251	0.035	<0.001	0.258	0.033	<0.001
Population per mile ($\times 1,000$)	-0.032	1.186		0.416	1.127		0.345	1.043	
Local population characteristics									
Unstable poor	22.814	4.894	<0.001	51.105	6.174	<0.001	28.920	5.149	<0.001
Stable wealthy	12.605	2.680	<0.001	8.548	3.191	0.007	9.927	2.817	<0.001
Immigrant Hispanic	-0.695	4.866		18.369	5.784	0.002	-3.764	4.985	
Rural majority	10.281	4.048	0.011	-4.380	4.466		4.623	4.025	
Lagged population characteristics									
Unstable poor	-19.673	5.758	<0.001	-33.402	7.119	<0.001	-23.885	5.879	<0.001
Stable wealthy	-6.472	4.342		6.973	4.648		-6.211	4.748	
Immigrant Hispanic	-17.787	6.116	0.004	9.266	7.155		-6.206	6.279	
Rural majority	-0.300	5.178		-24.583	5.765	<0.001	-1.975	5.516	
Local place density									
Off-premise outlets	0.563	0.139	<0.001	0.429	0.155	0.006	0.518	0.144	<0.001
Restaurants	0.038	0.088		-0.027	0.090		-0.032	0.084	
Bars or pubs	-0.164	0.183		0.194	0.198		0.076	0.173	
Nonalcohol other retail	0.037	0.040		0.008	0.022		0.001	0.028	
Nonalcohol food retail	-0.936	0.575		-1.055	0.670		-0.747	0.639	
Nonalcohol services	-0.667	0.198	<0.001	-0.515	0.251	0.040	-0.190	0.228	
Vacant housing	0.013	0.003	<0.001	0.017	0.003	<0.001	0.003	0.003	
Lagged place density									
Off-premise outlets	0.657	0.268	0.014	0.463	0.275		0.037	0.305	
Restaurants	-0.052	0.096		-0.039	0.188		-0.010	0.091	

Variable	Accident injuries			Assault injuries			Traffic injuries		
	<i>b</i>	SE	<i>P</i>	<i>b</i>	SE	<i>P</i>	<i>b</i>	SE	<i>P</i>
Bars or pubs	-0.212	0.380		0.134	0.400		-0.446	0.672	
Nonalcohol other retail	0.043	0.075		-0.148	0.073	0.043	0.017	0.071	
Nonalcohol food retail	-0.869	0.959		0.808	0.978		-1.288	1.039	
Nonalcohol services	-0.277	0.288		-0.052	0.422		0.362	0.370	
Vacant housing	0.004	0.006		0.005	0.007		-0.003	0.006	
Over-dispersion	0.180	0.029	<0.001	0.164	0.034	<0.001	0.255	0.035	<0.001
Zero inflation	-2.275	0.194	<0.001	-2.395	0.208	<0.001	-3.035	0.328	<0.001
Residual spatial autocorrelation	0.008	0.015		-0.001	0.001		-0.001	0.002	

Note: *p*-values are shown only for effects significantly different from zero at the 0.05 level.

Zero Inflated Negative Binomial Models for Injuries due to Accidents, Assaults, and Traffic Crashes Among Young Adults Aged 21 to 29 ($n = 1,646$)

Table 4

Variable	Accident injuries			Assault injuries			Traffic injuries		
	<i>b</i>	SE	<i>P</i>	<i>b</i>	SE	<i>P</i>	<i>b</i>	SE	<i>P</i>
Constant	1.050	0.043	<0.001	0.014	0.061		0.722	0.054	<0.001
Population and density									
Population ($\times 1,000$)	0.183	0.004	<0.001	0.181	0.006	<0.001	0.170	0.005	<0.001
Population per mile ($\times 1,000$)	-3.674	0.424	<0.001	-2.932	0.599	<0.001	-3.073	0.499	<0.001
Lagged population and density									
Population ($\times 1,000$)	0.057	0.010	<0.001	0.064	0.013	<0.001	0.086	0.011	<0.001
Population per mile ($\times 1,000$)	1.103	1.099		1.235	1.353		1.132	1.151	
Local population characteristics									
Unstable poor	26.665	4.075	<0.001	39.529	5.351	<0.001	17.126	4.012	<0.001
Stable wealthy	0.404	1.968		12.373	2.772	<0.001	3.881	2.308	
Immigrant Hispanic	-10.021	3.799	0.008	2.315	4.716		-9.832	3.682	0.008
Rural majority	-3.460	3.138		-17.335	4.138	<0.001	-6.480	2.832	0.022
Lagged population characteristics									
Unstable poor	-14.197	4.603	0.002	-1.003	5.900		-2.460	4.697	
Stable wealthy	1.969	3.459		4.537	4.315		5.030	3.749	
Immigrant Hispanic	-0.377	4.543		2.892	6.391		-9.442	4.951	
Rural majority	0.427	4.176		-14.578	5.655	0.010	1.636	4.039	
Local place density									
Off-premise outlets	0.368	0.121	0.002	0.320	0.150	0.033	0.412	0.125	0.001
Restaurants	-0.066	0.047		-0.093	0.079		0.201	0.059	<0.001
Bars or pubs	0.172	0.169		0.550	0.192	0.004	-0.128	0.170	
Nonalcohol other retail	0.011	0.016		0.024	0.018		0.035	0.025	
Nonalcohol food retail	-0.394	0.380		-0.423	0.600		-0.916	0.400	0.022
Nonalcohol services	-0.077	0.120		-0.557	0.190	0.003	-0.412	0.151	0.006
Vacant housing	0.010	0.002	<0.001	0.017	0.002	<0.001	0.000	0.003	
Lagged place density									
Off-premise outlets	-0.187	0.262		-0.364	0.302		-0.604	0.245	0.014
Restaurants	0.038	0.110		-0.043	0.088		-0.053	0.114	

Variable	Accident injuries			Assault injuries			Traffic injuries		
	<i>b</i>	SE	<i>P</i>	<i>b</i>	SE	<i>P</i>	<i>b</i>	SE	<i>P</i>
Bars or pubs	-0.301	0.515		0.266	0.491		0.013	0.482	
Nonalcohol other retail	-0.002	0.051		0.063	0.071		0.123	0.057	0.032
Nonalcohol food retail	-0.263	0.754		-1.077	0.875		-2.044	1.002	0.041
Nonalcohol services	0.035	0.267		0.216	0.237		0.329	0.314	
Vacant housing	0.004	0.005		0.003	0.005		-0.004	0.005	
Over-dispersion	0.139	0.012	<0.001	0.231	0.024	<0.001	0.141	0.016	<0.001
Zero inflation	-1.738	0.115	<0.001	-2.792	0.256	<0.001	-1.983	0.148	<0.001
Residual spatial autocorrelation	0.001	0.002		-0.001	0.007		-0.001	0.016	

Note: *p*-values are shown only for effects significantly different from zero at the 0.05 level

Table 5

Elasticities for Significant Alcohol Outlet Density Effects

Outlet type	Underage youth (18 to 20)			Young adults (21 to 29)		
	Accident injuries	Assault injuries	Traffic injuries	Accident injuries	Assault injuries	Traffic injuries
Local density						
Off-premise	0.153	0.163	0.142	0.100	0.093	0.114
Restaurants	-	-	-	-	-	0.072
Bars or pubs	-	-	-	-	0.043	-
Lagged density						
Off-premise	0.166	-	-	-	-	-0.155
Restaurants	-	-	-	-	-	-
Bars or pubs	-	-	-	-	-	-