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Ecological models of alcohol outlets and violent assaults: crime potentials and geospatial analysis

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ABSTRACT

Aims Empirical tests of relationships between alcohol outlets and violence are generally conducted with statistical controls for correlates related to characteristics of people and the places in which they live. Crime potentials theory asserts that certain subpopulations are disposed to participate in criminal activities (population potentials) and certain neighborhoods are more likely to be places where crimes occur (place potentials). The current study assesses the degree to which measures of the different geographic distributions of these potentials contribute to violent crime. **Design** Cross-sectional data on hospital discharges for violent assaults were obtained for residents of 1637 zip code areas in California. Assault rates were related to measures of population and place characteristics using spatial statistical models corrected for spatial autocorrelated error. **Findings** Rates of assault were related to population and place characteristics within zip code areas, and with characteristics of populations living in adjacent zip code areas. Assault rates were greater in densely populated, poor minority urban areas with greater residential instability. Assault rates were also greater in zip code areas adjacent to densely populated urban areas. Assault rates were related significantly to local densities of off-premise alcohol retail establishments, not bars. However, densities of bars moderated substantially effects related to local population characteristics. Bars were related significantly to violence in unstable poor minority areas and in rural middle-income areas of the state. **Conclusion** Population and place characteristics are associated with rates of violence across spatial areas. Alcohol outlets directly affect and moderate potentials for violence associated with socio-demographic groups.

Keywords Alcohol availability, crime, geographic information systems, geostatistical analysis, violence.

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INTRODUCTION

Explanations for the rates of violent crime observed in community settings focus usually upon one of two features of neighborhoods: (1) characteristics of the populations living in those neighborhoods or (2) characteristics of the places in which they live. Crime theories also assert generally that characteristics of people, places, or both people and places are related to observed rates of violence in neighborhood areas (Sampson & Lauritsen 1994). Social normative theories and theories of social disorganization tend to focus upon population characteristics associated with violence such as residential mobility, minority status and poverty (Shaw & McKay 1947; Sampson, Raudenbush & Earls 1997). Among these populations, normative constraints against violence are difficult to establish and maintain. Routine activities theories tend to focus upon the characteristics of places that are associated with violence, such as areas with abandoned housing or greater retail activity (Felson 1987; Felson *et al*. 1997). In these places, lack of guardianship (e.g. police presence) is related to greater opportunities for violence. The dividing lines between people and place characteristics are, of course, somewhat arbitrary. Most theorists incorporate both characteristics in their explanations of violence and assert that interactions between people in places support violent acts (Garofalo 1987; Stark 1987; Greenberg & Schneider 1994).

Two recent papers have focused upon the integration of theories and suggest the mechanisms by which characteristics of places, typically from the perspective of routine activities theory, and aspects of populations, typically from the perspective of social disorganization theory, affect crime rates across community areas. Smith, Glave Frazee & Davison (2000) noted that both population and place characteristics may affect crime rates (in this case robbery) differentially across community areas. Rice & Smith (2003) noted that both approaches are necessary to the development of adequate ecological models of crime (in this case with regard to automotive theft). Both these contributions indicate that spatial diffusion may characterize the distribution of crime rates around certain geographic areas of communities, with crime rates in one area affecting crime rates in nearby areas. Although these studies indicate that some spatial processes may characterize aspects of the spatial distribution of crime, they do not test whether spatially disparate measures of population and place characteristics contribute to crime rates independent of effects related to local population and place characteristics. As will be argued here, there are good theoretical reasons to believe that spatial relationships between populations and places are important to the prediction of crime. The challenge for ecological researchers is to develop models of the spatial relationships of people and places to predict crime (in our case violence) across community areas.

Crime potentials

One way in which people and place characteristics have been related to violence has been in terms of 'crime potentials'; the likelihood that crime will be exhibited in an area as a function of various ecological features (Brantingham & Brantingham 1993, 1999). Environmental criminologists have been concerned with those features of the environment that lead to greater or lesser crime rates and, like much other work in criminology, observe that it is a combination of people and place characteristics that underlie crime rates. Individual actors are ultimately responsible for crime in their communities, and so crime potentials related to population characteristics are important and represent the production of crime from people living in community areas. While acknowledging that populations can and do interact between areas, it is clear that in the absence of a population with suitable characteristics that enable crime, no crime will be observed. Place characteristics are also recognized as facilitating crime by focusing human activities in locations where social control is weaker and social interactions that lead to crime are more likely. So, while people are ultimately responsible for the generation of crime, crime rates can be moderated by place characteristics. Logically, higher rates of crime should occur in places where greater population and place potentials co-occur, accelerating rates of crime at these points.

In addition to the separate contributions of people and place characteristics to crime, it can be observed that many crimes occur in places adjacent to populations that take advantage of crime opportunities that exist away from places where members of these populations actually live and work. Places where crime rates are high may be at the 'edges' of neighborhoods, on the boundaries between one neighborhood and another or within retail and business areas between neighborhoods, where people interact for one reason or another (Brantingham & Brantingham 1993). Importantly, edges are areas themselves and may be areas where few people live, but many people visit in the course of their daily activities. At the level of streets and blocks within communities these areas are often very visible. Across larger areas, such as neighborhoods, Census tracts and zip codes, these areas will be progressively less well defined. Nevertheless, among these larger units some will represent predominantly residential, others predominantly retail areas suitable for the examination of crime potential theory in these geographic contexts. Across larger geographic units the predictions of crime potential theory still obtain, but with less geographic precision and with edge areas less well resolved.

As suggested by this discussion, the most important aspect of crime potential theory is its claim that unique spatial relationships underlie the geographic distributions of crimes across neighborhood areas. In the case of interpersonal violence, individuals likely to commit violent acts may interact with others in locations where violence is enabled by place characteristics. Thus, three relevant questions are suggested by this theory: (1) 'what population characteristics are associated with greater levels of violence?'; (2) 'in what places is violence more likely to be exhibited?'; and (3) 'what are the spatial features of ecological data that relate people and place characteristics to violence?'. The first question has been addressed in considerable depth by criminologists (see Sampson & Lauritsen 1994). Preliminary answers to the second question have been suggested by routine activity theorists (Felson *et al*. 1997). Provisional answers to the third question have been suggested by environmental criminologists (Brantingham & Brantingham 1993, 1999) and are the subject of this study.

The role of alcohol outlets

One of the places where interpersonal violence appears to occur more often than others is in and around locations of alcohol outlets. Alcohol outlets, particularly bars, are places that attract clientele more likely to be involved in violent acts (e.g. young males). Bars are often located in community areas with less guardianship (e.g. retail areas), offer opportunities for social interactions that may lead to violence (Haines & Graham 2005), and provide an intoxicating substance that appears to disinhibit aggression among males (Pihl, Lau & Assaad 1997; Giancola, Saucier & Gussler-Burkhardt 2003). Indeed, across repeated empirical studies over the past 14 years the locations of bars and taverns (Roncek & Maier 1991; Scribner, MacKinnon & Dwyer 1995; Gorman *et al*. 2001; Lipton & Gruenewald 2002) and sales through alcohol outlets (Stevenson, Lind & Weatherburn 1999) have been correlated with higher rates of violence. These studies suggest consistently that violence among at-risk populations may be greater in areas in which alcohol is more available. Alcohol outlets may be selected by (or 'attract', Parker 1993a,b; Alaniz *et al*. 1998) social groups at risk for violence. Notably, similar arguments have been put forward to support empirically observed cross-sectional relationships between rates of violence and locations of off-premise establishments (e.g. liquor or grocery stores, Scribner *et al*. 1995). These effects, however, may be related to other problems associated with these environments (e.g. illegal drug activity and prostitution: Alaniz *et al*. 1998).

Spatial dynamics and geospatial analysis

One unique feature of current ecological studies relating alcohol outlets to violent outcomes is their attention to the spatial relationships between locations of alcohol outlets, populations of probable offenders and violence. Building upon the earlier observation that rates of violence are autocorrelated spatially between community areas, Alaniz *et al*. (1998), Gorman *et al*. (2001) and Lipton & Gruenewald (2002) have shown that characteristics of populations living in adjacent neighborhoods are related to rates of violence around outlets. Greater population densities in surrounding areas and greater levels of impoverishment among these populations appear related to greater rates of violence in neighborhoods in which bars are located. Much as predicted from crime potential theory, people and place potentials measured across spatial areas are related to greater levels of violence. These relationships are taken as implying unique population dynamics that underlie violence in different community areas (e.g. the mixing of disparate populations in local drinking establishments).

Much of the growth in ecological analysis over the past 25 years has been supported by the development of improved procedures for the analysis of ecological data. These analysis procedures enable unbiased statistical analyses of ecological data in the presence of spatial autocorrelated measurement error and the exploration of spatial lag effects, the effects of variables measured in one unit upon outcomes measured in another. Procedures developed for the purpose of testing hypotheses about the spatial relationships between alcohol outlets and motor vehicle crashes related to drinking and driving (Gruenewald *et al*. 1996) also provide the technology necessary to test spatial models of outlets and violence (see Lipton & Gruenewald 2002). Such analyses move the field forward by identifying structural relationships among measures between units that would otherwise lead to misspecification bias (Lipton *et al*. 2003).

The current study

The spatial relationships between populations living in different places that support violence across neighborhoods of communities are, to this point, understood poorly and rarely recognized empirically (see Morenoff, Sampson & Raudenbush 2001). The current study takes a step towards improving our understanding of these relationships by developing explicit models of the people and place characteristics that underlie one measure of violence across the state of California, overnight hospitalizations for violent assaults. The primary goals of the research are to understand the people and place characteristics that underlie hospitalizations for assaults and elucidate some of the spatial relationships of populations and places that shape assault rates across the state. An important secondary goal is to assess the effects of alcohol outlets independent of measures of other retail markets. One concern among alcohol researchers has been that alcohol outlets serve as markers for other retail activities, activities that could also be related to violence.

METHODS

This study takes a purely population-based ecological approach to the examination of rates of violence across community areas. Aggregate archival data on population and place characteristics were collected for all 1637 zip code areas in the state of California for the year 2000. These data sources included all hospital discharges identified as related to an assault event among California residents aged 15 years and older that resulted in at least one overnight stay, the primary outcome measure used in the study.

Geographic basis

The geographic basis for the study was regions defined using electronic maps of the state of California obtained from Claritas (Ithaca, NY, USA). The US postal zip code polygons in these electronic maps were created by Geographic Data Technologies (GeoLytics Inc. 2004). GDT zip code maps provide 100% coverage of the state by estimating the most likely post office which will serve an outlying area and by creating artificial zip codes for low or no population areas such as state parks or national forests. Some zip codes are essentially non-spatial, including point locations for post office boxes, major government offices, specific mail facilities and military mail. The 1637 zip codes in the current study were those areas that had some geographic extent, were connected contiguously within the state (i.e. excluded islands) and were inhabited (eight areas had no population). Appropriate to the representation of physical access to alcohol and contacts with or exposure to other retail establishments and vacant housing (see below), 'densities' were defined on the metric of roadway miles (see also Lipton & Gruenewald 2002). For this purpose TIGER line files for Census 2000 redistricting were assigned spatially to zip code polygons in ARCVIEW version 8.2 using nearest distances, and lengths of roadway segments were aggregated to zip code areas. The assumption made here is that individuals travel along roadway networks, encountering alcohol and other retail establishments, vacant housing and one another. Rendering the geography of any place as a network, rather than a two-dimensional plane, represents more suitably the distance metrics along which contacts between people and places occur for the types of activities studied here.

Hospital discharge data

Hospital discharge data were obtained from the California Office of Statewide Health Planning and Development and were geocoded to the zip code of the injured party's residence. These records provide information on all admissions that result in at least one overnight hospital stay, including International Classification of Diseases version 9 (ICD-9) diagnostic codes related to the hospital stay. Among these codes are 'E-codes', event codes that identify the cause of injury. E-coded 'assaults' identify injuries resulting from interpersonal violence (E960–E969). In California, E-codes are obtained from 99% of all admissions to hospitals in the state (Annest *et al*. 1998) and have a sensitivity and specificity of better than 90% in record check and patient follow-up studies (Meux *et al*. 1990; Meux 1993). These assaults are events that are more serious than an altercation that leads to a police call only because they require hospitalization and treatment. Assaults among those people 15 years of age and older were used in these analyses. Geocoding rates for those cases with California zip codes exceeded 99%.

Alcohol outlets

Data on the locations of alcohol outlets were obtained from California Alcohol Beverage Control. Outlet locations were geocoded to zip codes based upon street address of the establishment. Numbers of alcohol outlets by zip code were tabulated for off-premise establishments, restaurants and bars and pubs. Geocoding rates exceeded 98%. Density of outlets was calculated in units of number of outlets per roadway miles, reflecting the ease of access to these establishments.

Retail data

County business pattern data are collected annually by the US Department of Commerce and include an assessment of numbers of retail establishments within zip codes by type (NAIC, North American Industry Classification system codes). Numbers of non-alcohol retail establishments were tabulated for non-alcohol food retailers (e.g. butchers and snack food distributors), non-alcohol other retailers (e.g. clothing, department and hobby stores) and non-alcohol service industries (e.g. motels and other accomodations). These measures were converted to densities of establishments per roadway mile. Geocoding rates exceeded 99%.

Census data

Census variables that characterized both people and places were obtained from the Census 2000 Summary File 1, SF1, Census of Population and Housing (US Department of Commerce 2001) and Census CD 2000 Long Form Summary File 3, SF3 (release 2.0; GeoLytics, Inc. of E. Brunswick, NJ, USA). SF1 data were geocoded to internal points for each block; SF3 data were geocoded to internal points for each block group. Census blocks and block groups were assigned spatially to zip codes by matching internal points (usually block centroids) to zip code areas. Using this procedure, some aggregation error is inevitable due to blocks or block groups that span zip code edges. This will tend to induce bias in estimates within units and autocorrelated measurement error between units in statistical analyses of these data (corrected in the statistical analyses presented below). Aggregation error in the current study was relatively small: 96.0% of Census blocks and 93.8% of Census block groups fell within the zip code polygons defined for the study. These blocks and block groups covered more than 98.3% of the state's population.

With the exception of the measures of vacant housing and population size (number of people 15 years of age and older), variables from the Census identify the following population characteristics: (1) percentage unemployed (as a percentage of the total work-force); (2) percentage in poverty (population below poverty line); (3) percentage of female heads of household with children; (4) percentage of black (excluding Hispanic and multi-race designations); (5) percentage Hispanic (not exclusive of other racial designations); (6) percentage foreign-born; (7) percentage of owner-occupied housing (of all households); (8) percentage of households moved since 1999 (of all households); (9) percentage of households moved in past 5 years (of all households); (10) percentage married; (11) percentage of high school graduates (including high school equivalency); (12) percentage of college graduates (bachelor's degree or higher); (13) percentage of household income greater than $75 000 (of all households with income data); and (14) percentage of youth 15–29 years of age (distinguishing that subset of the population most involved in violent assaults). 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 versus less than \$20 000 divided by total number of households). A value of 100.0 on this measure reflects concentrated wealth and a value of −100.0 reflects concentrated poverty.

Two population measures were used in the analyses, population size and density (size per roadway mile). Population size, people aged 15 years old or older, was used to denominate the outcome measure providing an index of the prevalence of hospital discharges for assault among residents of zip code areas. The measure of population density was constructed to represent the compacting of persons within urban areas. For populations of constant size, numbers of people per roadway mile will reflect differences between relatively rural areas (communities spread out along roadway systems) and dense urban areas (communities of densely packed residences, such as multi-story apartments). The one place variable obtained from the census data, numbers of vacant housing units, was also converted to a density measure in units of roadway miles. As for alcohol outlets, vacant housing was denominated by roadway miles.

Data reduction

As noted in the Introduction, most ecological analyses of violence in the United States take the perspective that particular neighborhood characteristics are related to violence. Predominant among these characteristics are neighborhood disorganization, residential instability, immigrant and minority status and impoverishment (Sampson *et al*. 1997). These neighborhood characteristics are generally measured using a number of different Census-based variables and summarized using principal components and factor analytical techniques. In order to reduce the number of variables to be entered into the current analyses, with the exclusion of the population size and vacant housing measures, a descriptive analysis of the Census-based population characteristics available for the 1637 zip code areas was conducted (population weighted covariance structure analysis with oblique factor rotations). This analysis revealed that 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 of 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 were used to represent population characteristics in the following analyses.

Spatial analyses

The dependent measure for these analyses was the natural logarithm of numbers of assaults per 1000 population. Zip codes with no assaults were assigned a rate equal to 0.5/1000. Population characteristics were measured by population size, density (people per roadway mile) and the Census-based factor scores (here labeled 'unstable poor', 'stable wealthy', 'immigrant hispanic', 'rural majority'). Place characteristics were measured by densities of nonalcohol food, service and other retailers, densities of vacant housing, and alcohol outlet density (off-premise, restaurants and bars). Metrics of the independent measures were transformed to simplify the scaling of effects: population and population density were measured on a metric of 1000 people, all place variables in terms of 100 000 roadway miles and the factor scores on an arbitrary scale suitable to simplify the scaling of model coefficients. Estimated model coefficients were sensitive to biases due to dramatic variations in population size between units (up to three orders of magnitude). This source of heteroskedasticity was controlled through the use of appropriate variance weights prior to testing model hypotheses.

All independent measures (population and place) were obtained for each of the 1637 zip codes, and for every zip code adjacent to each zip code. The latter measures were aggregated across adjacent areas of each zip code and included as measures of spatial lagged effects, the effects of physically external (i.e. geographically adjacent) population and place characteristics on local rates of outcomes in each zip code. Thus, four different effects of local and lagged population and place characteristics were considered in the analysis models.

As suggested in the Introduction, ecological analyses of population data from geographic areas require statistical tests of, and possible statistical corrections for, spatial autocorrelated error, which is the tendency of errors in measurement to be correlated across adjacent geographic areas. Positive spatial autocorrelation generally leads to inflation of Type I errors. Negative spatial autocorrelation generally leads to inflation of Type II errors. The raw endogenous measure for this analysis, assaults per 1000 population, exhibited significant positive spatial autocorrelation (Moran coefficient (MC) = 0.399, $Z = 25.55$, $P < 0.001$; Bailey & Gattrell 1995). Consequently, nuisance parameter models that correct for spatial autocorrelated errors were applied to the estimation of relationships between population and place characteristics and rates of violence (Griffith 1988). Generalized least squares estimates of these models were obtained using proprietary software that enables diagnostics for outliers and highly leveraged cases in spatial analyses (Spatial Statistical System, Ponicki & Gruenewald 2003). One zip code area was eliminated from the study as a persistently high-leverage case throughout all analyses. No other highly leveraged cases were observed in the remaining analysis models and rates of outliers declined to less than 4% of cases in final analysis models. Smoothing of these outliers to local rates (i.e. spatial average of target and adjacent areas) had no substantive effects on the results of the analyses reported here. Finally, because these models also included a large number of possibly multicollinear covariates, condition indices for every model were assessed to diagnose the tolerance of model estimates (Greene 1993). The condition index for the final model (see below) was 17.86, elevated over usual levels, but not indicative of severe multicollinearity.

Spatial lag effects and spatial interactions

One of the primary goals of the current study is to delineate separate effects related to population and place characteristics measured in local areas, and in areas adjacent to each area in the study. Spatial lag effects refer to statistical relationships observed between variables measured in one place (e.g. a downtown area) and those measured in another (e.g. a suburb of a downtown area). The statistical detection of spatial lag effects is taken to imply spatial interactions of some (often unknown) form between aspects of the populations of these spatial units. For example, the populations living within some units may travel through others and be exposed to risks in those other places.

These informally conceptualized spatial interactions may or may not be examined explicitly in statistical models applied to spatial data. For example, the analysis model applied to the current data (equation 1) implies a theoretical model that represents violence as a simple production function related to population size, **P** (equation 2, see also Lipton & Gruenewald 2002):

$$[\mathbf{A}/\mathbf{P}] = \mathrm{a} + \mathbf{X} \times \mathbf{b} \quad (1)$$
$$\mathbf{A} = \mathrm{a} \times \mathbf{P} + [\mathbf{P} \times \mathbf{X}] \times \mathbf{b} \quad (2)$$

As indicated by equation 2, across geographic areas local populations, **P**, produce numbers of assaults and **A**, per unit time (1 year in this case). These rates of production are expected to be modified by local population and place characteristics, **X**, with the size of these effects expressed by the coefficient vector **b**. The convenience of equation 1 is the reduced multicollinearity is likely to be observed in statistical analyses of assault data. The benefit of theoretical equation 2 is its explicit representation of interaction effects that reflect how characteristics of populations and places are moderated by population size, $\mathbf{P} \times \mathbf{X}$. These interaction terms are not spatial lag effects and do not imply spatial interactions. However, consider the extended forms of these models in which both local, **X**, and spatially lagged (or adjacent) exogenous measures, $\mathbf{X}_{\text{-}1}$, are presented:

$$[\mathbf{A}/\mathbf{P}] = \mathrm{a} + \mathbf{X} \times \mathbf{b} + \mathbf{X}_{\text{-}1} \times \mathbf{c} \quad (3)$$
$$\mathbf{A} = \mathrm{a} \times \mathbf{P} + [\mathbf{P} \times \mathbf{X}] \times \mathbf{b} + [\mathbf{P} \times \mathbf{X}_{\text{-}1}] \times \mathbf{c} \quad (4)$$

Here, in equation 4, it is clear that lagged populations with their characteristics, or lagged places with their characteristics, both represented by measures in $\mathbf{X}_{\text{-}1}$, interact with local populations to produce assaults (equation 3 is the reduced form used in the current analyses). These spatial lag effects imply that local populations are either interacting with external populations to produce violence or are exposed to risks related to characteristics of external places (e.g. outlets outside of the local area). Seen in this light, the absence of lagged outlet and other place effects would simply suggest that densities of these lagged places are not related to the production of violence from local populations. On the other hand, the presence of substantive effects related to the composition of lagged populations would suggest that contacts between local and lagged populations may be of great importance.

RESULTS

Figure 1 presents thematic maps describing hospital discharges for assault per 10 000 population observed across zip code areas in the state. As shown in the figure, rates of violence were greatest in both rural and urban areas of the state. Examining the state map, rates of assault were greatest in a number of relatively poor rural and newly urbanized areas. In the north, these areas were exclusively rural, poor and with substantive minority populations (Hispanic and American Indian). In the south these areas were predominantly rural, poor and Hispanic, consisting of collections of small towns in largely desert environments. In the central part of the state, greatest rates of assault were observed around several moderate-sized cities (e.g. Bakersfield). These are areas in which a mixture of rural poverty and wealth co-occur. Examining the San Francisco Bay (top left) and Los Angeles Basin (bottom left) area maps, rates of assault were greatest in those environments noted conventionally in urban studies: areas of extreme poverty, showing signs of neighborhood disorganization, and residential instability.

Table 1 presents descriptive statistics for the original measures used in this study. A review of these statistics

Table 1 Descriptive statistics for measures used in analyses.

Measures	*Minimum*	*Maximum*	*Median*	*Mean*	*Standard deviations*
Assaults	0.000	159.00	2.000	8.298	15.261
Population (× 1000) (15 years or older)	0.001	75.336	11.581	15.808	15.534
Alcohol outlets					
Bars or pubs	0.000	57.000	2.000	3.842	5.360
Restaurants	0.000	216.000	10.000	18.654	23.680
Off-premise	0.000	122.000	10.000	16.139	17.093
Non-alcohol retail	0.000	315.000	11.000	29.005	42.212
Non-alcohol food	0.000	38.000	1.000	1.873	2.787
Non-alcohol service	0.000	91.000	4.000	7.209	9.655
Vacant housing units (× 1000)	0.000	16.601	0.270	431.121	746.397
Percentage					
Unemployed	0.000	69.053	6.635	7.916	6.168
In poverty	0.000	100.000	11.993	13.920	9.872
Female head of household	0.000	100.000	5.803	6.399	5.340
African American	0.000	87.757	1.563	4.600	8.714
Hispanic	0.000	100.000	15.732	23.815	21.883
Foreign-born	0.000	78.802	15.308	18.666	14.728
Owner-occupied housing	0.000	100.000	64.270	60.022	20.835
Moved in 15 months	0.000	100.000	19.044	19.699	8.541
Moved in 5 years	0.000	100.000	49.015	49.259	13.072
Married	0.000	87.712	57.329	56.516	9.457
High school graduates	0.000	100.000	82.487	77.707	17.870
College graduates	0.000	100.000	20.437	24.943	17.133
Incomes greater than 75 000	0.000	100.000	22.031	25.761	16.579
Index of concentrated income extremes	−100.000	100.000	39.817	39.312	27.215

provides a sense of the degree to which places varied in their population and place characteristics. For example, numbers of assaults varied from none to 159, population size from one to 75 336 people 15 years of age and older, and numbers of bars ranged from zero to 57. Populations living in these areas also varied substantially in many related characteristics including unemployment (from zero to 69%), foreign-born residents (from zero to 79%), income (from zero to 100% of households with incomes greater than $75 000 per year) and marital status (zero to 87.7% married). Much of this diversity is reflected in the ICE which exhibits the full extent of its possible range.

The primary questions for these analyses were whether there were separable and significant effects on rates of violence related to (a) population and place characteristics and (b) measures taken in local and lagged. When considered against the background of a simple model that included only a constant term, population size and population density, local population characteristics (Rao's likelihood χ^2, $G^2 = 140.08$, d.f. = 4, $P < 0.001$) and local place characteristics contributed significantly ($G^2 = 47.18$, d.f. = 7, $P < 0.001$) to the explanation of violence rates. Over and above these local characteristics, population characteristics in adjacent areas were related significantly to violence rates ($G^2 = 13.84$, d.f. = 5, $P < 0.001$), but place characteristics were not ($G^2 = 2.28$, d.f. = 7, $P < 0.943$). The findings from the resulting analysis model, including local place and local and lagged population characteristics, are shown in Table 2, model I. Greater rates of assault were related significantly to greater population size, lower population density and unstable poor areas. Rates of assault were lower in rural majority areas. Considering local place characteristics, densities of off-premise alcohol outlets were related positively to greater rates of assault. Considering lagged population characteristics, the size of adjacent populations was associated significantly with assaults.

Against the background of these analyses, the next question to be addressed was whether some areas were subject uniquely to the moderating effects of place characteristics on population potentials for violence. For this purpose, interaction terms representing the moderating effects of population characteristics upon the relationships between alcohol availability and violence were introduced into the analysis. Bar densities were significant moderators of local population effects ($G^2 = 23.48$, d.f. = 4, $P < 0.001$), while off-premise outlets ($G^2 = 6.56$, d.f. = 4, $P = 0.161$) and restaurants ($G^2 = 1.92$, d.f. = 4, $P = 0.750$) were not.

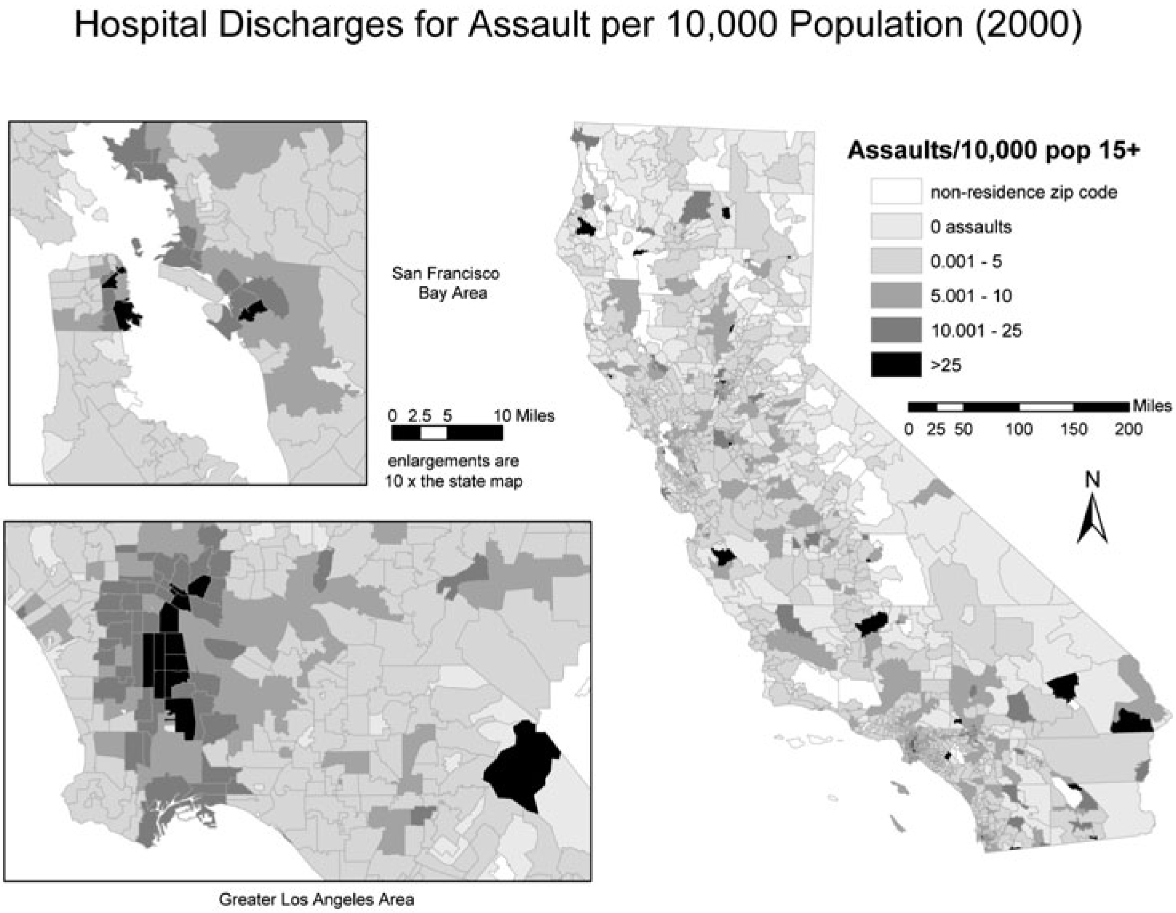

Figure 1 Hospital discharges for assault per 10 000 population (2000)

(Supplementary analyses showed that densities of other retail establishments and vacant housing were also unrelated to assaults.)

The results from the analysis model including bar interactions are shown in Table 2, model II. In this model, local population characteristics continued to be the primary determinant of rates of assaults across zip code areas. Greater rates of assault were related to greater population size, lower population density and unstable poor minority areas of the state. Rates of assault were greater in immigrant Hispanic areas of the state. Assault rates were also greater in areas adjacent to larger populations and lower in areas adjacent to zip codes with rural majority populations. None of the remaining local place characteristics were related significantly to assaults. Finally, rates of violence were greater in unstable poor and rural majority areas with greater numbers of bars. Rates of violence were less in stable wealthy and immigrant areas with greater numbers of bars. The effects of bar densities on violence were substantively moderated by local population characteristics. As shown at the bottom of the table, spatial autocorrelated error remained significant in these analyses and a substantive amount of variance in assault rates across zip code areas was accounted for by these models.

DISCUSSION

The results of these cross-sectional analyses support the basic assertions of crime potential theory that violence rates are a function of population characteristics, place characteristics and their interactions across spatial areas. This study provides support for previous research indicating that measures of population characteristics related to social disorganization are essential to understanding violence in community settings. Factor scores representing unstable poor, stable wealthy, immigrant Hispanic and rural majority areas were the strongest correlates of violence rates. These observations are in overall agreement with previous studies of social disorganization and violence (e.g. Sampson *et al.* 1997). As suggested by social disorganization theory, unstable poor and immigrant neighborhoods were places where violence was more likely to occur. Only populations living in rural majority areas showed lower risks for violence.

Table 2 Spatial regression model of hospital discharges for assault.

		Model I			*Model II*		
Variable group	*Variable name*	*b*	*t*	*P*	*b*	*t*	*P*
	Constant	−1.183	−5.121	£0.001	−1.309	−5.711	< 0.001
Local population characteristics	Population size (× 1000)	0.084	19.802	< 0.001	0.084	19.880	< 0.001
	Population density (× 1000)	−1.530	−2.790	0.003	−1.520	−2.714	0.003
	Unstable poor	65.889	4.707	< 0.001	62.233	4.390	< 0.001
	Stable wealthy	−1.117	−0.126	NS	16.484	1.706	NS
	Immigrant Hispanic	19.030	1.347	NS	30.178	2.080	0.019
	Rural majority	−30.600	−2.384	0.009	−23.600	−1.771	NS
Lagged population characteristics	Population size (× 1000)	0.023	2.933	0.002	0.016	2.105	0.018
	Unstable poor	0.791	1.145	NS	0.638	0.927	NS
	Stable wealthy	0.184	0.378	NS	0.204	0.421	NS
	Unstable immigrant	−0.918	−1.383	NS	−0.691	−1.047	NS
	Rural majority	−1.094	−1.831	NS	−1.494	−2.479	0.007
Local place characteristics	Off-premise outlet density	1.319	2.567	0.005	1.690	3.173	NS
	Restaurant density	0.310	1.049	NS	0.474	1.551	NS
	Bar density	−1.180	−1.180	NS	1.249	0.787	NS
	Other retail density	−0.018	−0.203	NS	−0.067	−0.751	NS
	Food retail density	−0.839	−0.662	NS	2.217	1.475	NS
	Service retail density	0.150	0.262	NS	−0.337	−0.552	NS
	Vacant housing density	−0.010	−0.722	NS	−0.007	−0.519	NS
Local premise interactions	Bars × unstable poor				204.999	2.769	0.003
	Bars × stable wealthy				−192.140	−2.645	0.004
	Bars × immigrant Hispanic				−468.126	−4.393	< 0.001
	Bars × rural majority				212.514	3.367	< 0.001
Spatial autocorrelation	ρ	0.213	5.926	< 0.001	0.189	5.182	< 0.001
Pseudo R^2		0.551			0.557		

The results also support the observation that selected place characteristics are related to violence rates. Importantly, these associations were related to the availability of alcohol. Densities of off-premise establishments, but not bars, remained positively associated with rates of violence independent of a wide array of population and place characteristics for which alcohol outlets act as markers. Alcohol outlets are typically located in relatively poor, low socio-economic status areas of communities, near to places where there is a great deal of other retail activity. Controls for these covariates were included in the current study, thus excluding them as an explanation for effects related to off-premise establishments. Notably, effects related to bar densities were not significant.

Contextual effects related to locating alcohol outlets in different neighborhoods were investigated by testing for moderating effects of neighborhood characteristics upon outlet–violence relationships. The results of these analyses suggest that the impacts of bar densities on violence are context-specific. Greater numbers of bars in unstable poor and rural majority areas were associated strongly with increases in violence rates. This supports the suggestion of crime potential theory that the combination of these potentials for violence are far more than the sum of their parts, and offers additional support for the conclusion that bars provide additional opportunities for violence in poor minority areas of US communities. Clearly, violence prevention at these establishments (Haines & Graham 2005) or regulatory efforts to control the growth and spread of specific alcohol outlets in these contexts (Stockwell & Gruenewald 2004) are called for.

The statistical effects related to bars, however, also appeared to have unexpected 'protective' effects. Greater numbers of bars in stable wealthy and immigrant Hispanic neighborhoods were related to lower rates of violence. This could be interpreted to represent the different uses of these outlets in these different neighborhoods. Bars in stable wealthy neighborhoods may be patronized by drinkers less prone to violence. Bars in immigrant Hispanic neighborhoods may be used in culturally different ways, unrelated to drinking patterns that result in violence. The statistical limitations of the current study prevent further analysis of these effects. However, as an important statistical note, inclusion of any other place covariates in the model, representing interactions between local population characteristics and alcohol or other retail outlets, resulted in the elimination of these ostensibly significant effects. In contrast, regardless of these different specifications of the analysis model, greater numbers of bars in unstable poor and majority rural areas remained significantly related to greater violence rates.

The contextual effects observed with respect to bar densities may throw some light upon an issue that remains at the center of any explanation of alcohol's role in violence observed at the community level. Larger densities of bars, and alcohol outlets in general, have often been viewed as one of a number of signs of disorganized neighborhoods, places where individuals prone to violence may commit violent acts ('broken windows', Sampson & Lauritsen 1994; Sampson & Raudenbush 2004). In this framework, bars and other outlets are viewed as having a rather undifferentiated social influence upon people living and recreating within different neighborhoods. On the other hand, individuals living in different neighborhoods may use bars and other alcohol outlets in different ways. Similar bars in different neighborhoods may be used for different purposes: in violent neighborhoods as a focus of violent activities, in quiet neighborhoods as a focus for non-violent activities. Thus, the mixing of violent people in violent places can accelerate violence rates (Alaniz *et al*. 1998). This second hypothesis argues that social selection is one of the operative principals by which bars become violent places (Haines & Graham 2005). The empirical observation of differential effects of bar densities on violence across different kinds of neighborhoods supports this hypothesis and calls for a fine-grain analysis of the use of these places for drinking in different neighborhoods.

Limitations of the study

One of the implications of the current study is that there are specific spatial interactions that support violence in and around alcohol outlets. The interpretative framework provided by crime potential theory, its implications with regard to spatial interactions and the results of the current study support this dynamic interpretation. The data for this study are, however, decidedly not dynamic. At best, these cross-sectional spatial data provide an opportunity to argue that some spatial dynamic underlies distributions of crime outcomes across community areas. The observation of statistical associations between lagged population characteristics and local rates of violence is a good example of one such observation. Whether local and lagged populations share supportive norms for violence (through information diffusion) or whether direct physical interactions between these populations increase rates of violence (through direct physical contact), some spatial interaction must be taking place between populations, and these interactions must be taking place in time. The obvious limitations of these arguments when based upon cross-sectional data can only be addressed in longitudinal studies using spatial panel data.

Other important limitations of the current study include (1) the absence of adequate controls for other local environmental characteristics that may also be related to violence; (2) the focus upon one limited form of violence (i.e. hospital discharges); and (3) probable differences to be observed in the geographic distributions of violent incidents versus the residential locations of the victims of violent acts. Obviously, many other characteristics of populations and places may be related to the violence experienced by residents of different areas of communities. Among these may be specific types of alcohol outlets that might also be related to violence such as liquor stores; but perhaps the most important among these are the local characteristics of illegal drug markets, the distribution systems of which are often closely tied to violence. Data on the geographic distributions of these markets would be very helpful. Current spatial analyses of drug markets show that drug sales are concentrated in disadvantaged neighborhoods (Saxe *et al*. 2001), often those in some state of decay (LaGrange 1999), and rates of sales and possession may be related to population characteristics of those living within (e.g. poverty) and outside (e.g. wealth) specific neighborhoods (see LaScala *et al*. 2005). The association of violence with drug markets suggests that some of the assaults seen in this study were related to these market activities; activities found in much the same neighborhoods as indexed by the covariates included here.

In addition, the current study focuses upon one unique measure of violence, victims appearing in hospital after a violent assault. The focus on this measure limits the generalizability of the study to this specific subset of violent acts. Many assaults, particularly simple assaults, involve little or no physical contact and most do not result in overnight hospital stays (in California, police arrests for assault occur at 10 times the rate of hospital discharges for assault). It should be recognized that the nature of the relationships of the current assault measure to local population and place characteristics, based as it is upon residential locations of victims, may have a very different geographic signature from that of most other measures of violence. The most common measures of violence, based on police incident reports and arrests, are geolocated by locations of incident or arrest events, places that are not often identified with victims' residences. Distinctly different spatial relationships are implied by these different measures.

Finally, with regard to population studies conducted with politically defined geographic units, it is important to recognize that the shapes and sizes of these units sometimes affect outcomes of such studies. While there has been remarkable coherence in results across studies relating outlets to violence rates across many different kinds of geographic units, from Census block groups to zip codes, the units used here are larger than most and vary in size. These could lead to some unobserved biases in analyses using zip codes as the unit of analysis (Bailey & Gattrell 1995).

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