INTRODUCTION

There is considerable evidence that alcohol outlet density is associated with negative health outcomes (Popova et al., 2009; Theall et al., 2009) and increased rates of violence (Britt et al., 2005; Gruenewald and Remer, 2006; Livingston, 2006). Recent research showed not only that this association remains when controlling for other ecological features of neighborhoods, but that community characteristics like social organization (Pridemore and Grubesic, 2012a), land use (Pridemore and Grubesic, 2012b) and ethnic composition (Gruenewald et al., 2006) moderate the strength of the harmful effect of outlet density on violence. Nevertheless, questions remain as to whether outlet density is truly responsible for increased crime, or if the outlet–violence association is only the result of alcohol availability (Stockwell and Gruenewald, 2004). Similarly, there are concerns that the outlet–violence association may also be the result of routine activity, where neighborhoods with outlets and other businesses simply bring potential victims and offenders together (Briscoe and Donnelly, 2001; Gruenewald, 2007; Freisthler et al., 2008; Parker et al., 2011).

The argument that the association between alcohol outlet density and violence is primarily driven by alcohol availability is a reasonable one. Simply put, the argument is that alcohol itself is to blame, not alcohol outlets. It is widely acknowledged that a significant dose–response relationship exists between blood alcohol level and aggression/violence (Mcdonald et al., 2005; Duke et al., 2011). Thus, greater alcohol outlet density increases alcohol availability, encourages niche drinking environments, increases consumption and clusters violence-prone drinkers together (Gruenewald, 2007; Grubesic and Pridemore, 2011; Livingston, 2011). One way to account for this relationship, albeit imperfect, would be to include a control for the volume of alcohol sales within a community. Although sales do not necessarily correspond to consumption, if a relationship between outlet density and violence remained after controlling for the amount of alcohol sold, this would suggest there is something unique about outlets themselves, or their density, that contributes to the generation of crime. Unfortunately, in the USA alcohol sales data are rarely available for geographic units smaller than states (Gruenewald, 2011). With some exceptions (Stevenson et al., 1999; Norstrom, 2000; Bye, 2007; Stockwell et al., 2009; Liang and Chikritzhs, 2011), this lack of sales data is true for other nations as well.

It is also possible that the connections between alcohol outlet density and violence are simply driven by routine activities (Cohen and Felson, 1979). In this context, alcohol outlets function no differently than any other commercial outlet. Regardless of the product being sold, outlets (alcohol or otherwise) tend to cluster in commercial districts within cities because of land-use and zoning regulations (Gruenewald et al., 2012; Pridemore and Grubesic, 2012b). As a result, these agglomerations bring together a steady stream of people (i.e., potential victims and offenders) in the same space. In other words, there is nothing special about being an alcohol retailer or about the density of alcohol outlets. What matters for higher crime is simply being a retailer or the greater density of commercial retail outlets (Felson, 1987). Further, even if alcohol outlets are potentially risky, their density covaries with other types of risky retailers associated with higher crime rates (Ford and Beveridge, 2004; Rengert et al., 2005) such as check-cashing stores (Kubrin et al., 2011) and pawn shops (Miles, 2008). Interestingly, although a handful of prior studies have controlled for the density of commercial retailers (Gruenewald and Remer, 2006; Gruenewald et al., 2006; Freisthler et al., 2008), none have explicitly controlled for the presence of risky retailers.

Collectively, these are valid arguments and they represent two major remaining limitations that leave statements about the relationship between alcohol outlet density and violence vulnerable to criticism. In this study, we contribute to the existing literature by being the first to address each of these limitations by controlling for an indicator of local alcohol expenditures and for the presence of other retailers, including risky retailers. If an association between alcohol outlet density...
and violence remains after controlling for these characteristics, this would substantially strengthen evidence that the outlet–violence association is valid. It would also suggest there is something unique about alcohol outlets or their concentration that helps generate crime.

METHODS

Study area

Philadelphia, Pennsylvania, was our study area, and our unit of analysis was the block group. In 2010 Philadelphia had a population of about 1.5 million residents in 1816 block groups. Block groups are the smallest unit for which socio-economic data are available for public use from the Census Bureau.

Measures

Our dependent variable was aggravated assault, which the Uniform Crime Report defines as an unlawful attack by one person on another, often with a weapon, for the purpose of inflicting severe bodily injury (FBI, 2010). We obtained geocoded assault data from the Philadelphia Police Department (PPD). As described below, we estimated models using both spatial and negative binomial regression. For the latter, we used assault counts as the dependent variable. For the former, we used assault density (i.e. assaults per square mile). As detailed by Priddemore and Grubesic (2013), the use of assault density can offer advantages over a per capita measure. In short, a per capita measure where the denominator is the population size makes a somewhat unrealistic assumption that all assault victims and offenders are residents of the index block group, i (or tract, ZIP code, etc.). Conversely, the spatial measure provides a more standardized and geographically meaningful comparison of assaults between units, and thus a better gauge of any local association between alcohol outlets and assaults. For example, if block groups A and B have the same number of residents (1000) and outlets (12) and block group A is 0.10 square miles and B is 2.5 square miles (a common range in cities), a per capita measure provides the same score for A and B. This fails to capture residents’ spatial proximity to outlets. Conversely, the spatial metric provides scores of 120 and 4.8 outlets per square mile for block groups A and B, respectively, providing a more meaningful measure of spatial exposure to outlets. Further, because the Census Bureau attempts to maintain the average population of block groups at 1500, there is some level of exposure standardization within block groups as well.

The main independent variables were total, on-premise and off-premise alcohol outlet densities. Off-premise outlets were defined as the 52 state-controlled liquor stores plus establishments—usually delis and convenience stores—with an ‘E’ license (allowing them to sell beer for off-premise use) or a ‘D’ license (distributors allowed to sell beer for off-premise use). Outlet locations were obtained from the Pennsylvania Liquor Control Board for November 2010. We excluded airports, distilleries, large-scale distributors and sacramental wine vendors, leaving a total of 2016 outlets. All outlets were geocoded successfully using the ArcGIS software (ESRI, 2012).

The two key control variables in this study were alcohol expenditures and the presence of non-alcohol retailers. Alcohol sales data, especially at small units of analysis, are generally unavailable in the USA, and so we used a proxy: household alcohol expenditures as a proportion of household income. This measure is derived from the Bureau of Labor Statistics’ Consumer Expenditure Surveys (CEX) and provided by ESRI (2010a). To compensate for the relatively small CEX survey bases and the variability of single-year data, expenditures are averaged over 2 years.

There are several compelling reasons for using the expenditures data. First, the CEX data provide a viable snapshot of money exchanged for alcoholic beverages, by households, at a very fine geographic scale. Thus, regardless of the accuracy with which these data represent consumption or local sales, expenditures data do reflect varying levels of alcohol-related commerce within a region. Second, CEX data are driven by choices. The products that consumers decide to purchase are influenced by local market characteristics, lifestyles and preferences. Thus, the expenditures data reflect local preferences and provide one way to track an important facet of consumer activity within a region. From an operational perspective, we chose to standardize the expenditures variable by dividing by the number of households in a block group to get spending per household, then dividing by household income to get the proportion of household income spent on alcohol. While it might be tempting to suggest that this is simply an adjusted measure of wealth and/or poverty, again, we suggest that it is a viable reflection of alcohol-related commerce for a region.

The presence of non-alcohol retailers was captured in two ways. Using land use data acquired from the city of Philadelphia, we created a location quotient (LQ) (Hildebrand and Mace, 1950) for general commercial retailers. The advantage of using an LQ is that it compares the proportion of commercial land use in each block group to the proportion of commercial land use in the entire city. The LQ is estimated as follows:

$$LQ_i = \frac{b_i / b}{B_i / B}$$

where $b_i =$ square footage of land use in category $i$, $b =$ square footage of land use for all categories in the block group, $B_i =$ square footage of land use for category $i$ in the city and $B =$ square footage of land use for all categories in the city. The second indicator was a measure of businesses that may also increase crime risk. This was measured as an LQ for check cashing stores, pawn shops and convenience stores (combined) for each block group.

We controlled for several other covariates of urban crime rates. These included the proportion of all households that were female-headed and had at least one child under the age of 18, the proportion of households with an income below $15,000 (a measure of poverty), the proportion of the population aged 15–29, the proportion of the population that were African Americans, population density, a diversity index to measure ethnic heterogeneity, the proportion of all housing units that were vacant, a residential land use LQ and the density of public transportation nodes. All variables are for 2010 and were obtained from ESRI (2010b), with the exception of the latter two, which came from the city of Philadelphia.

ANALYSIS

We estimated spatially lagged regression models with a queen’s contiguity matrix, allowing us to model spatial dependence...
between units and account for geographic influence of nearby observations (Anselin, 1988; Millar and Grueenewald, 1997; Pridemore and Grubesic, 2013). To ensure normality, a square root transformation of the dependent variable, assault density, was implemented. To remedy hints of multicolinearity in the independent variables, we created a factor containing female-headed households and percent black, each of which loaded at >0.70. We also estimated models using negative binomial regression to gauge stability of our results. This is because aggravated assault is rare and some block group populations are small, resulting in low assault counts. Under these conditions, a negative binomial estimator is most appropriate (Gardner et al., 1995). All models were estimated with Anselin et al., 2006 and Stata (2013).

RESULTS

Figure 1 displays the geographical distribution of aggravated assault and alcohol outlet density by block group in Philadelphia. The map on the left is shaded light to dark with increasing assault density and shows the location of all outlets. The map on the right is shaded light to dark with increasing alcohol outlet density. There is wide variation in both. Aggravated assault density ranged from 0 to 1235 per square mile, with a mean of 135, a median of 91 and an interquartile range of 25% = 26.57, 50% = 91.60 and 75% = 202.02. Alcohol outlet density ranged from 0 to 1035 per square mile, with a mean of 28, a median of 0 and an interquartile range of 25% = 0, 50% = 0 and 75% = 37. A defining characteristic of the spatial distribution of assault density is the ring of violence around Center City, Philadelphia’s focal point for dining, entertainment and cultural events. The Moran’s I for assault density was 0.44 (P < 0.001), suggesting assaults are spatially clustered. Figure 2 identifies this clustering of assaults more precisely by showing the local indicator of spatial association (Anselin, 1995), which corroborates the visual patterns in Fig. 1. Center City is not devoid of violence, but the city’s most violent regions are elsewhere. The highest concentration of alcohol outlets is in Center City, although there are pockets of higher densities in North, South and West Philadelphia. Again, this is corroborated by a Moran’s I of 0.42 and local clustering of outlet densities throughout the city (not shown).

Table 1 shows descriptive statistics for dependent, key independent and control variables. Table 2 displays results for spatial regression models estimating the association between aggravated assault density and total, on-premise and off-premise alcohol outlet densities. Each model explained about 48% of the variance in assault density. The spatial autoregressive coefficient was significant in all models, although the strength of its impact was marginal. The association with aggravated assault density was significant for total outlet density (b = 0.004, P = 0.04) and off-premise outlet density (b = 0.018, P = 0.04). The P-value for on-premise outlet density (b = 0.003, P = 0.07) suggested an association but did not allow for strong conclusions to be drawn. Thus, even after controlling for alcohol expenditures and for the densities of other retailers and other potentially risky retailers, there remains a positive and significant association between aggravated assault density and total and off-premise alcohol outlet density, and probably for on-premise outlet density.

Looking at the results for our key control variables, the effect of our proxy for alcohol sales, the proportion of

![Fig. 1. The spatial distribution of alcohol outlets and assaultive violence in Philadelphia, 2010.](https://academic.oup.com/alcalc/article-abstract/48/5/613/209448/56413209448?key=guest)
household income spent on alcohol for each block group, was positively and significantly associated with assault density in all models. The measure of the presence of other retailers, the commercial LQ, was also positively and significantly associated with aggravated assault density in all models. We found no association between the density of potentially risky retailers and aggravated assault density. Results for the negative binomial models using count data were identical.

Finally, for the purpose of sensitivity analysis, we estimated three additional models that included (a) only alcohol outlets, (b) alcohol outlets and main control variables and (c) alcohol outlets, main and additional control variables. The results fall in line with those found in Table 2, and clearly illustrate that alcohol outlet density is strongly associated with violence, population density and socioeconomic deprivation.

METHODOLOGICAL LIMITATIONS

There are a number of methodological limitations that need to be mentioned. First, the consumer expenditure data (CEX) are not an ideal proxy for alcohol consumption or sales. Three potential problems exist with the expenditures variable. First, household expenditures data for high-quality alcohol (e.g. fine spirits) may far exceed those for low-quality beverages (e.g. malt liquor) because of pricing differences. Unfortunately, this does not reflect alcohol consumption levels. Second, the CEX surveys rely on accurate self-reporting, and alcohol expenditures may not engender accuracy because of the social stigmas associated with heavy alcohol consumption (Room, 2005). Third, residents spend some of this money in other block groups. Nevertheless, the measure behaved as expected: it was positively and significantly associated with aggravated assault density in all models.

A second limitation to this study is that there is no clear definition of off-premise outlets for Philadelphia. Pennsylvania has a wine and liquor monopoly (Grubesic et al., 2012), and in 2010 there were 52 state-operated liquor stores in Philadelphia. Beyond this, things are less clear. In our disaggregated models, in addition to state stores we included off-premise outlets with D and E licenses. D licensees are allowed to sell beer to the public for off-premise use. Still, they are not traditional liquor stores and do not bring the same traffic. E licensees are allowed to sell beer for off-premise use, but these are mostly delis and corner stores. By law their main business must be food preparation and service and they must have table places for at least

![Fig. 2. Hot spots of aggravated assaults in Philadelphia, by block group (2010).](https://academic.oup.com/alcalc/article-abstract/48/5/613/209448/48565613/208448)
30 people (PLLC, 2012). Finally, R licensees are traditional on-premise outlets like bars and restaurants, but they are also allowed to sell small quantities of beer for off-premise use. This system makes it difficult to disaggregate cleanly into on- and off-premise outlets, and measurement decisions other than the ones we made are possible. This is likely partially responsible for the on-premise outlet density result, where a P-value of 0.07 suggests an association but does not allow for strong conclusions to be drawn. A large number of our off-premise outlets (those delis and corner markets with an ‘E’ license) can also be considered on-premise outlets.

**DISCUSSION**

There is a consistent association between alcohol outlet density and violence in the empirical literature, even after controlling for a number of other community characteristics suspected to influence crime rates or to be confounded with outlet density (Britt et al., 2005; Gruenewald and Remer, 2006; Livingston, 2006). One critique of this literature is that studies that fail to control for sales volume and for the density of other retailers obscure the true connection between outlets and violence.

Other factors that are also usually absent from these models, such as proximity to public transportation hubs that attract heavy foot traffic and may host other illicit activities like drug sales that increase the risk of violence (Block and Block, 1995, 2000), are also important to control for when testing an association between alcohol outlet density and violence.

In this study, we found that transportation nodes and potentially risky retailers had no association with violence. However, our measure of local alcohol expenditures and the measure of general commercial activity were both positively and significantly associated with assault density. The first association provides general support for the hypothesis that the outlet–violation association is partially due to alcohol availability and alcohol-related commerce in a community. The second association supports the hypothesis of routine activity theorists, in that commercial clusters bring together potential offenders and victims, generating crime. However, the real value of the analysis presented in this paper is that even after controlling for these confounders and alternative explanations, the positive and significant association between aggravating assault density and total and off-premise (and probably on-premise) alcohol outlet density remained. Thus, our results are consistent with findings that show (a) an association between alcohol outlet density and violence in other US cities (Speer et al., 1998; Nielsen and Martinez, 2003; Zhu et al., 2004; Pridemore and Grubesic, 2013), (b) a stronger association for off- relative to on-premise outlets (Gruenewald et al., 2006; Pridemore and Grubesic, 2012a,b, 2013) and (c) an association between outlet density and harm remained after controlling for alcohol expenditures, mimicking the results when one controls for local sales in the rare situations in which sales data are available (Gruenewald et al., 1999; Stevenson et al., 1999; Liang and Chikritzhs, 2011).

**IMPLICATIONS**

If alcohol itself is not the sole cause of the association between outlets and violence, and if being in a commercially

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**Table 2. Spatial regression model results**

<table>
<thead>
<tr>
<th>Spatial regression models (queen contiguity)</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>(1.238) [2.555] **</td>
<td>(1.276) [2.637] **</td>
<td>(1.355) [2.864] **</td>
</tr>
<tr>
<td>W_SQRTASSDEN (spatial autoregressive coefficient)</td>
<td>(0.081) [2.641]</td>
<td>(0.080) [2.628] **</td>
<td>(0.080) [2.627] **</td>
</tr>
<tr>
<td>Alcohol outlet density</td>
<td>(0.003) [2.101]</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>On-premise alcohol outlet density</td>
<td>–</td>
<td>(0.003) [1.814]</td>
<td>–</td>
</tr>
<tr>
<td>Off-premise alcohol outlet density</td>
<td>–</td>
<td>–</td>
<td>(0.018) [2.054] *</td>
</tr>
<tr>
<td>Main control variables</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Alcohol expenditures as percent median HH income</td>
<td>(40.023) [2.190] *</td>
<td>(39.517) [2.162] *</td>
<td>(38.735) [2.123] *</td>
</tr>
<tr>
<td>Commercial LQ</td>
<td>(0.594) [6.738] ***</td>
<td>(0.595) [6.750] ***</td>
<td>(0.599) [6.803] ***</td>
</tr>
<tr>
<td>Additional control variables</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Potentially risky retailers LQ</td>
<td>(–0.000) [–1.542]</td>
<td>(–0.000) [–1.548]</td>
<td>(–0.000) [–1.592]</td>
</tr>
<tr>
<td>Public transport stop density</td>
<td>(0.008) [0.047]</td>
<td>(0.006) [0.033]</td>
<td>(0.003) [0.919]</td>
</tr>
<tr>
<td>Diversity index</td>
<td>(0.000) [4.338] ***</td>
<td>(0.018) [4.311] ***</td>
<td>(0.018) [4.283] ***</td>
</tr>
<tr>
<td>Population density index</td>
<td>(0.000) [15.136] ***</td>
<td>(0.000) [15.133] ***</td>
<td>(0.000) [15.100] ***</td>
</tr>
<tr>
<td>Residential medium LQ</td>
<td>(2.060) [7.019] ***</td>
<td>(2.056) [7.004] ***</td>
<td>(2.044) [6.968] ***</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.481</td>
<td>0.480</td>
<td>0.481</td>
</tr>
<tr>
<td>Rho</td>
<td>0.081</td>
<td>0.081</td>
<td>0.081</td>
</tr>
<tr>
<td>Standard error</td>
<td>4.592</td>
<td>4.593</td>
<td>4.592</td>
</tr>
<tr>
<td>AIC</td>
<td>10,719.9</td>
<td>10,720.1</td>
<td>10,720.1</td>
</tr>
<tr>
<td>Breusch–Pagan test</td>
<td>150.199*</td>
<td>149.767*</td>
<td>151.208*</td>
</tr>
</tbody>
</table>

(coefficient) [z-value].

*P < 0.05.

**P < 0.01.

***P < 0.001.

*Significant at P < 0.07.
dense area is not wholly to blame, then what is it about alcohol outlets that lead to higher violence rates? Again, evidence is growing that greater outlet density has a strong connection to crime. This association has been addressed at length for bars and clubs, including important contextual effects, but less is known about off-premise outlets even though several recent studies have shown them to be more strongly associated with violence than bars (Gruenewald et al., 2006; Branas et al., 2009; Pridemore and Grubesic, 2013).

Part of the effect may have little to do with outlets but instead may be due to patrons consuming alcohol in, or coming (home) drunk to, private settings where there is little regulation over their behavior. This is shown, for example, in coming (home) drunk to, private settings where there is little regulation over their behavior. This is shown, for example, in coming (home) drunk to, private settings where there is little regulation over their behavior. This is shown, for example, in coming (home) drunk to, private settings where there is little regulation over their behavior. This is shown, for example, in coming (home) drunk to, private settings where there is little regulation over their behavior. This is shown, for example, in coming (home) drunk to, private settings. This is shown, for example, in coming (home) drunk to, private settings (Block and Block, 1995). In Philadelphia, they are usually delis and corner stores, and Branas et al. (2009) describe them like islands in the night: ‘bright but unattended spaces’ and activity centers that often provide ‘the only well-lit spaces among nonworking street lamps, vacant properties, and dark residences’. Relative to bars, with bouncers and staff nearby and on alert, the spaces around off-premise outlets are largely unregulated.

It is also important to recognize that not all outlets are equally troublesome. As with bars, there are likely characteristics of off-premise outlets that put some at higher risk for violence than others (Graham, 2006; Snowden, 2012). For example, when discussing hot spots of crime, Sherman et al. (1989) ask if certain places ‘vary in their capacity to help cause crime, or merely in their frequency of hosting crime that was going to occur somewhere anyway?’ In this sense, the mounting evidence suggests that alcohol outlets do not simply host or attract crime that would occur somewhere else anyway, but that they generate crime that would not otherwise take place. This might be partially due to the nature of the surrounding neighborhood (Pridemore and Grubesic, 2012a), as disorganized communities are less able to make demands for responsible retailing practices. Still, outlet, staff, patron and environmental characteristics could play a role (Snowden, 2012). Does the off-premise outlet sell single cans of beer? How much shelf space is devoted to alcohol relative to other goods? How old is the staff and how many are working at the most dangerous times? Is there an alley or vacant lot nearby where patrons might gather after buying alcohol?

Regardless of the mechanisms, at this stage it is difficult to believe that alcohol outlet density is not causally related to violence. While the results of this paper cannot infer this relationship with absolute certainty, we are among the first (especially in the USA) to estimate a model that controls for a proxy for sales and for potentially important confounders like commercial activity, risky retailers and transportation nodes, and our findings suggest that alcohol outlets not only attract crime but likely generate crime that otherwise would not occur.

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