ORIGINAL ARTICLE

Evaluating the Effects of the Introduction of Off-Sale Alcohol Outlets on Violent Crime

Daikwon Han and Dennis M. Gorman*

Department of Epidemiology & Biostatistics, School of Rural Public Health, Texas A&M Health Science Center, College Station, TX 77843, USA
*Corresponding author: Tel.: +1-979-458-8059; Fax: +1-979-458-1877; E-mail gorman@srph.tamhsc.edu

Abstract — **Aims**: To examine the effects on violence of a policy change that ended prohibition of off-sale alcohol outlets in Lubbock, Texas. **Methods**: Time-series analysis of violent crime data from police records comparing the periods before and after the policy change. **Results**: The effect of the policy change on both total violent crime and aggregated assault was small and did not approach statistical significance. **Conclusions**: Increased availability of alcohol through off-sale premises may not influence the type of violence reported to the police in Lubbock, Texas.

INTRODUCTION

In recent years, a number of studies have been published that assess the effects of changes in local alcohol policies, such as those affecting hours and days of sale, on both alcohol consumption and alcohol-related harmful effects (see, Hahn *et al*., 2010 and Middleton *et al*., 2009 for comprehensive reviews). However, we know of no studies that have examined the effects on violence of changes in local licensing policy affecting alcohol outlet density (AOD). For example, a systematic review conducted by Campbell *et al*. (2009) of the effects of AOD on alcohol-related harmful effects identified just four studies of national or local licensing policy changes that resulted in increased density, and none of these assessed effects on violence. Likewise, the systematic review conducted by Popova *et al*. (2009) contained no studies that examined the effect on violence of a change in licensing policy related to AOD.

While both of these systematic reviews concluded that there exists an association between AOD and violence within communities, the evidence in support of this conclusion came from cross-sectional studies (e.g. Gorman *et al*., 2001; Zhu *et al*., 2004; Gruenewald *et al*., 2006) or longitudinal studies that assessed gradual increases in density over time (e.g. Gruenewald and Remer, 2006), not evaluations of policy changes that resulted in an abrupt increase in AOD. Campbell *et al*. (2009) found that all but 1 of the 15 cross-sectional studies that they reviewed showed a positive association between combined on- and off-sale outlets and violent crime. In the case of the four studies that assessed just on-sale premises and the six that assessed just off-sale premises, each one was found to report a positive association with violent crime.

However, a recent study by Toomey *et al*. (2012) came to a somewhat different conclusion about the AOD literature based on an assessment of studies that differentiated the effects of off-sale density from those of on-sale density. Specifically, they argued that the results were inconsistent at best, noting that only about half of the studies that examined either off-sale density or on-sale density and violent crime found a positive association. In their subsequent analysis of data from the city of Minneapolis, they found that the association between AOD and violent crime was stronger and more consistent for on-premise outlets than for off-premise outlets.

Specifically, they found that while the association between on-sale AOD and each type of violent crime assessed (total, assault, rape and robbery) was significant and of similar strength, the associations between off-sale AOD and total violent crime and rape were not statistically significant and those with robbery and assault were weaker than were found for on-sale outlet density. This led them to conclude that the association between AOD and violence may not simply be driven by increased availability of alcohol as suggested by availability theory (Single, 1988), but rather may be caused in part by the segmentation of drinkers into certain types of high-risk drinking environments as suggested by Gruenewald (2007).

The present study used time-series analysis to assess the effects that a large and sudden increase in off-sale outlet density had on violent crime in the City of Lubbock, TX. Availability theory (which posits that the consumption of alcohol will increase as availability increases and this, in turn, will lead to a rise in alcohol-related problems; Single, 1988) would lead one to anticipate an increase in violent crime following such a change. If, however, the context within which drinking occurs is important in explaining the association between alcohol availability and violence, then one might not expect an increase in off-sale outlets to lead to increased violence, or at least, as suggested by the findings of Toomey *et al*. (2012), not to all forms of violence.

DATA AND METHODS

Study site

The study was conducted using data pertaining to the city of Lubbock, TX (estimated 2011 population = 233,740, plus ~31,000 students at Texas Tech University). Lubbock was, until 1972, the largest 'dry' city in the USA. In April of that year, restaurants and bars were permitted to sell alcohol for on-premise consumption. However, off-sale outlets remained illegal within the city limits. Outside of the city limits such outlets were permitted and these came to be concentrated along a highway south of the city. This area, which was incorporated into the city in 2006, comprised five large warehouse-type stores. On 9 May 2009, the residents of Lubbock approved a ballot proposition that ended the prohibition of the sale of alcohol from off-sale premises. Following

a delay of several months brought about by two unsuccessful legal challenges to the ballot results, the Texas Alcohol Beverage Commission issued off-sale licenses to 77 stores on 23 September 2009. Many of these licenses were issued to an already existing retail store (such as *7-Eleven*) that was able to commence sale of alcohol beverages immediately. At the first anniversary of the introduction of off-sale licenses in the city, 141 stores had received permits.

The city of Lubbock provides a good setting from which to assess the effects of a change in alcohol policy as it is geographically isolated and surrounded by counties that are sparsely populated and limit the sale of alcohol. The closest population center to the north of Lubbock is Amarillo, which is 124 miles away. The nearest cities after this (Oklahoma City, Fort Worth, Albuquerque and Las Cruces) are 300–400 miles away. In addition, the eight counties that surround Lubbock have low population density and three are totally 'dry' (i.e. the sale of alcohol beverage is illegal). None of the remaining five is totally 'wet': about half of the precincts in four of these countries are dry, and the one county that has no dry precincts allows only off-premise sale of beer and wine.

Data

Monthly counts of violent crime data were obtained directly from the Lubbock Police Department for the period January 2006 through December 2011. The new alcohol licensing policy that introduced off-sale premises in the city went into effect on 23 September 2009, so the time series was divided into a pre-policy period (January 2006–August 2009) and a post-policy period (September 2009–December 2011). A total of 9214 incidence cases of violent crime occurred during the entire study period, with 5977 cases for the 44-month pre-off-sale period and 3237 crime cases for the 28-month post-off-sale period. The monthly rates per 10,000 residents of all violent crime combined (assault, robbery, rape and murder) and assault separately were calculated using the mid-year population estimates obtained from the U.S. Census Bureau (US Census Bureau, 2012). The population of Lubbock increased steadily at an annual rate of ~1.6% over the course of the study period; this is above the US average, but slightly below the Texas State average of 2%. We assessed assault separately as well as in combination with the other three types of violent crime as some previous studies have focused only on this form of violence (e.g. Lipton and Gruenewald, 2002; Livingston, 2008), and it has been shown to be associated with off-sale AOD (Toomey *et al.*, 2012). In addition, it was the only category of violence for which we had a sufficient number of incidents to use in a subtype analysis.

Data analysis

Autoregressive integrated moving average (ARIMA) intervention time-series models were used to assess the onset (abrupt or gradual) and duration (permanent or temporary) of the effects of the change in licensing laws on the two violent crime outcomes (total and assaults only) (Box *et al.*, 1994). Of primary interest was whether there was a change in the level of either time series associated with the introduction of off-sale premises in the city, independent of time trends/seasonality and/or normal fluctuations. A pre–post

indicator variable 'level' defined as 0 prior to September 2009 and values >0 during the post-off-sales period was created to assess the presence of an intervention effect. We were also interested in whether there was any significant change in the trend following the policy change, and the possible impact of this on the patterns of violent crime during the post-off-sale period. Specifically, we tested two possible types of change in trend—an abrupt/permanent and a gradual/permanent change of the intervention (McDowall *et al.*, 1980). To assess the abrupt change in trend after the introduction of off-sale premises, an additional variable 'interaction' (a product of the time variable and indicator variable of 0, 1) was included in the model. To test for a gradual change in trend, the interaction variable was calculated as the product of time and the indicator variable that was coded as 0 before the intervention and gradually increased above >0 with the value of 1 in the last month of the post-policy change period.

Among the most important steps in building a time-series model are to check for temporal autocorrelation and stationarity (Chatfield, 2004). Both regular and seasonal differencing and transformation methods were applied to the data series to remove trends and/or seasonality. Plotting the correlogram indicated that the data series required differencing for stationarity; thus we used first-differencing to remove the effects of local trends and seasonal differencing at lag 12 to control for seasonality in the subsequent analyses of the data series. Types of ARIMA process—autoregressive (AR) and moving average (MA) parameters—were estimated with the pre-policy change data series based on the examination of the autocorrelation function (ACF) and the partial autocorrelation function (PACF). A final model with an AR term of 1 and an MA term of 1 with seasonality component was then selected, and the intervention component was added to the full model. Following the decision about the noise terms, model fit was further assessed using the AIC values for competing models. Residuals were checked for normality and independency using diagnostics measures, and the Ljung–Box Q test was used to test for residual autocorrelation and corresponding P-values for the white-noise test were included in the analysis (Ljung and Box, 1978). Estimated intervention effects indicating shift in level at the point of the policy change were identified, and two types of change in trend—abrupt and gradual change in violent crime—were compared using the ARIMA routines in Stata (Stata Corporation, College Station, TX, USA).

RESULTS

Descriptive summary data (mean, standard deviation, minimum and maximum values) of monthly violent crime and assault rates during the pre-policy change and the post-policy change time periods are presented in Table 1. Violent crime ranged from 3.4 to 9.1, with a monthly average rate of 5.9 per 10,000. Assault ranged from 2.4 to 7.0, with a monthly average of 4.2 per 10,000 over the entire 6-year period. Higher rates of violent crime and assault were observed during the pre-policy change period (6.4 and 4.7, respectively), compared with the post-policy change period (5.1 and 3.5, respectively).

Figure 1 shows the monthly patterns of violent crime and assault rates (per 10,000) from January 2006 through December 2011. Both data series varied substantially by month, especially in the early part of the pre-policy change data series. Overall decreasing trends of both violence outcomes were observed during the entire period. Months with higher or lower rates varied by year, and by pre- and post-policy change periods. However, rates were generally higher in May and July and lower in November and February, indicating some form of seasonal trend. Following the introduction of off-sale outlets into the city, the magnitude of monthly variations became smaller and a more stable pattern of similar trends was observed compared with the patterns in the pre-policy change period.

Table 2 presents the estimated intervention effects and two possible impact patterns of abrupt and gradual change in trend on violent crime and assault using the ARIMA time-series models. Estimates and standard error of the coefficient, P-values for both intervention effects (level) and two types of change in trend (interaction) are given in the table. The estimated effect of the policy change which introduced off-sale premises into the city in September 2009 represent a small increase in the violent crime rate (0.41) and a modest increase in the rate of assault (4.60), but neither of these changes approached statistical significance ($P = 0.93$ and $P = 0.68$, respectively). As for the analysis of changes in trend over the 28 month post-policy period, neither abrupt nor gradual change was statistically significant for both violence outcomes. Diagnostic measures for white-noise tests using the Ljung–Box Q statistic are also presented in the last two columns of Table 2. These indicate that the time-series models were successful in removing residual autocorrelation.

DISCUSSION

Before discussing the implications of the results of this study, its limitations should be acknowledged. First, the data come from one fairly isolated city in north-west Texas and the findings reported may not be generalizable beyond this setting. Secondly, although the focus of the study was on a policy change that led to a large overnight increase in the number of off-sale outlets in the city, such outlets were not entirely absent from the city prior to this change. As noted in the introduction, there was a small concentration of such outlets to the south of the city in an area that was incorporated into Lubbock in 2006. Also, while three of the eight counties surrounding the city were dry at the time of the policy change, five others allowed the sale of alcohol in some precincts and one of these allowed alcohol to be sold

Table 1. Descriptive summary statistics of monthly violent crime and assault rates (per 10,000 population) in Lubbock, Texas (2006–2011)

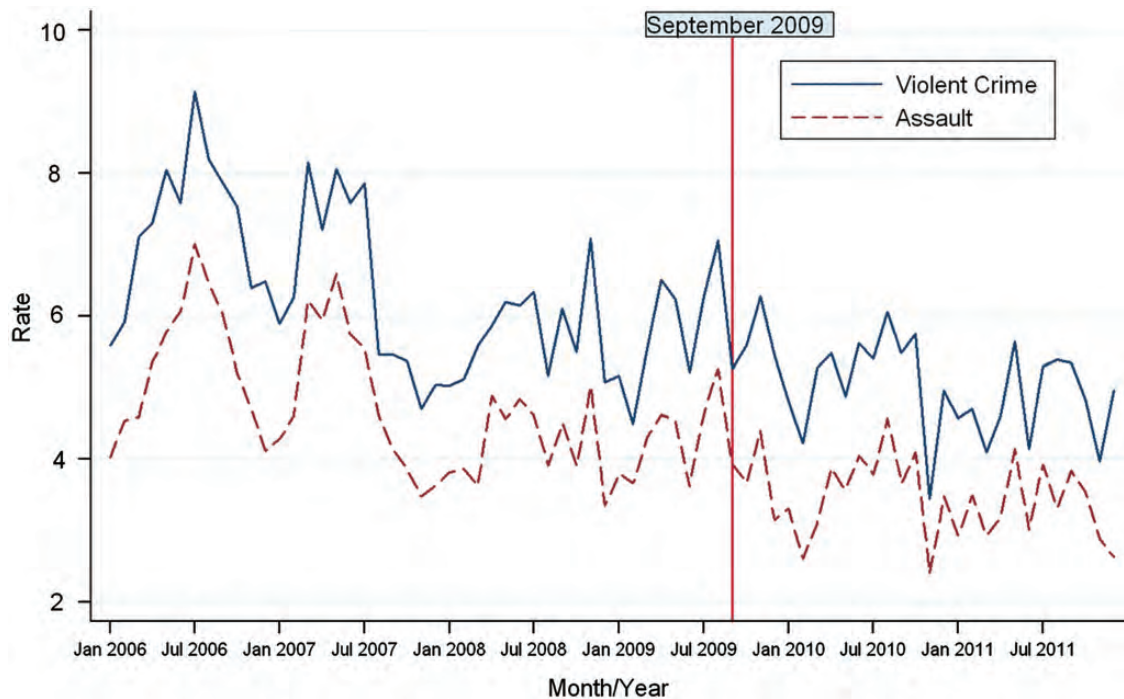|	Mean	SD	Minimum	Maximum
Violent crime				
Pre-off-sales outlets (January 2006–August 2009)	6.4	1.1	4.5	9.1
Post-off-sales outlets (September 2009–December 2011)	5.1	0.7	3.4	6.3
Entire time period (January 2006–December 2011)	5.9	1.2	3.4	9.1
Assault				
Pre-off-sales outlets (January 2006–August 2009)	4.7	0.9	3.4	7.0
Post-off-sales outlets (September 2009–December 2011)	3.5	0.6	2.4	4.6
Entire time period (January 2006–December 2011)	4.2	1.0	2.4	7.0

Fig. 1. Monthly patterns of violent crime and assault rates (per 10,000 population) in Lubbock, Texas, before and after the policy change introducing off-sale outlets in September 2009.

Table 2. Estimated intervention effects and impact patterns (abrupt and gradual change in trend) on violent crime and assault rates

	Estimate	SE	P-value	Q Test[a]	P-value
Violent crime					
Intervention effect (level)	0.41	4.83	0.93		
Abrupt change in trend (interaction)	−0.001	0.01	0.86	28.67	0.38
Gradual change in trend (interaction)	0.04	0.02	0.08	29.62	0.33
Assault					
Intervention effect (level)	4.60	11.01	0.68		
Abrupt change in trend (interaction)	−0.01	0.02	0.65	31.18	0.26
Gradual change in trend (interaction)	0.03	0.04	0.52	32.39	0.22

[a]Ljung–Box test for auto-correlated residuals.

only from off-sale premises. Thus, residents of Lubbock who wanted to consume alcohol at home or in some other off-site venue could obtain it prior to the policy change of September 2009, although this would have necessitated them having to drive to an off-sale premise. A third limitation of the study is that no measures of alcohol sales and consumption were included in the analysis, and therefore, we were unable to address the extent to which the introduction of off-sale outlets in the city led drinkers to modify their place of purchase (from on-sale to off-sale) and how this affected the amount of alcohol consumed.

A final issue that needs to be considered in the interpretation of the findings presented above is that the data used in this study to assess violence come from official police statistics. While such data are widely used in studies of AOD and violence, they may be much better suited to assessing the effects of on-sale AOD than the effects of off-sale AOD. The violence that occurs in or around a public setting such as a bar is more likely to come to the attention of the police than is violence that occurs in a private setting such as a home. It seems reasonable to assume that most alcohol purchased at an off-sale premise is consumed in private in the home of the purchaser or that of a friend or relative. If such consumption leads to violence, this will be less visible than that which occurs in a bar or on the streets surrounding a bar, and hence, it is less likely to be reported to the police. Such acts of violence, for example, domestic violence, may result in incidents that appear in other data sources such as hospital discharge data and these may be more appropriate for use in studies of off-sale alcohol outlets and violence.

The latter issue also has bearing on the theoretical interpretation of the results of our study. Most studies of the association between AOD and violence are implicitly or explicitly based on availability theory, i.e. the idea that consumption will increase as availability increases and this, in turn, will lead to a rise in both excessive drinking and alcohol-related harmful effects (Single, 1988; Stockwell and Gruenewald, 2001). Our finding of no effect on violent crime following the rapid introduction of off-sale alcohol outlets into the city of Lubbock clearly does not support this theory. While this may at first seem surprising, the finding is in line with the evidence reviewed by Toomey et al. (2012), which shows that half of the cross-sectional studies that have examined the relationship between the density of off-sale alcohol outlets and violent crime found no relationship.

More recently, some alcohol researchers have tried to move beyond simply examining the role of consumption in generating violence and explore in greater detail the effects of drinking environments on violent behavior. For example, both Gruenewald (2007) and Livingston et al. (2007) focus more explicitly on the drinking environment and the characteristics of this that increase the risk of violence in and around alcohol outlets. Specifically, Gruenewald (2007) has developed a more explicit ecological theory of alcohol outlets and alcohol-related harmful effects (called 'niche theory'), proposing that the sellers of alcohol market their products to specific segments of the drinking population and that different types of drinkers select or assort into different types of drinking environments, some of which are more conducive to the generation of violence than others. Toomey et al. (2012) interpreted the weaker association they observed between off-sale outlet density and violent crime compared with on-sale outlet density and violent crime in Minneapolis as supportive of niche theory, arguing that the type of assaultive violence that predominates in police data may be more likely to occur in and around on-sale establishments that have a concentration of heavy drinkers. This would also support the null findings that we observed in the present study.

The theory proposed by Livingston et al. (2007) also has a more explicit ecological focus than availability theory, emphasizing the effects of neighborhood context on drinking and alcohol-related harmful effects such as violence. Of most relevance to the current findings is their idea of an 'amenity effect' that explains the association between AOD and violence. This refers to the negative impact of licensed premises on the communities in which they operate, especially in terms of the types of individuals that they attract into a neighborhood. Livingston et al. (2007) note that both on-sale premises and off-sale premises can produce an amenity effect, but point out that this requires them attracting in people who will consume alcohol in the neighborhood and interact with one another. This is especially relevant to the findings of the current study concerning the effects of the off-sale policy in Lubbock, since many of the licenses that were issued were to stores that were already in operation selling other goods. Thus, the issuing of these off-sale licenses did not fundamentally change the appearance of these neighborhoods (except, perhaps, in terms of the advertisements shown in the store windows) and, since the alcohol would not be consumed on the premises of the store, they did not lead to an influx of intoxicated people interacting with one another. To the extent that the new licenses had an impact on violence, this would be through a mechanism that Livingston et al. (2007) refer to as a 'proximity effect', that is by making alcohol more available and therefore increasing consumption.

Exactly how such increased consumption generated by off-sale premises would affect the rates of violent crime in a city is unclear. On the one hand, since alcohol purchased for off-sale consumption can be consumed in locations far from the outlet at which it was acquired and long after its acquisition, one might expect any violence that off-sale purchases help generate to be both spatially and temporally diffused throughout the city. Alternatively, certain types of drinking behavior may lead to such violence concentrating in certain places and at certain times. For example, the phenomenon known as 'pre-drinking' (Labhart et al., 2012; Wells et al.,

2009), in which drinkers consume relatively large quantities of alcohol at home before visiting bars and clubs (where alcohol is more expensive), could lead to an increase in violence in and around on-sale outlets. Such an increase in violence would be the result of off-sale consumption and not on-sale consumption, but this association would not be identified in an analysis (such as that presented here) focused only on alcohol outlet type and location. Unfortunately, as noted above, we did not have access to data pertaining to alcohol sales and consumption. Such data would be needed in order to better test hypotheses generated by theories that differentiate the effects of increased alcohol availability on violence via increased consumption from those that are mediated through effects of drinking environments and context.

In conclusion, increased availability of alcohol in the city of Lubbock through off-sale premises did not influence the rate of violence that is reported to the police. These findings support the view that the context within which drinking occurs is important in explaining the association between alcohol availability and acts of violence.

REFERENCES

Box GEP, Jenkins GM, Reinsel GC. (1994) *Time Series Analysis, Forecasting and Control*. Englewood Clifs, NJ: Prentice Hall.

Campbell CA, Hahn RA, Elder R *et al*. (2009) The effectiveness of limiting alcohol outlet density as a means of reducing excessive alcohol consumption and alcohol-related harms. *Am J Prev Med* **37**:556–69.

Chatfield C. (2004) *The Analysis of Time Series: An Introduction*. New York: CRC Press.

Gorman DM, Speer PW, Gruenewald PJ *et al*. (2001) Spatial dynamics of alcohol availability, neighborhood structure and violent crime. *J Stud Alc* **62**:628–36.

Gruenewald PJ. (2007) The spatial ecology of alcohol problems: niche theory and assortative drinking. *Addiction* **102**:870–78.

Gruenewald PG, Remer L. (2006) Changes in outlet densities affect violence rates. *Alcoholism Clin Exp Res* **30**:1184–93.

Gruenewald PG, Freisthler B, Remer L *et al*. (2006) Ecological models of alcohol outlets and violent assaults: crime potentials and geospatial analysis. *Addiction* **101**:666–77.

Hahn RA, Kuzara JL, Elder R *et al*. (2010) Effectiveness of policies restricting hours of alcohol sales in preventing excessive alcohol consumption and related harms. *Am J Prev Med* **39**:590–604.

Labhart F, Graham K, Wells S *et al*. (2012) Drinking before going to licensed premises: an event-level analysis of predrinking, alcohol consumption, and adverse outcomes. *Alcoholism Clin Exp Res*. doi: 10.1111/j.1530–0277.2012.01872.x

Lipton R, Gruenewald PJ. (2002) The spatial dynamics of violence and alcohol outlets. *J Stud Alc* **63**:187–95.

Livingston M. (2008) Alcohol outlet density and assault: a spatial analysis. *Addiction* **103**:619–28.

Livingston M, Chiikritzhs T, Room R. (2007) Changing the density of alcohol outlets to reduce alcohol-related problems. *Drug Alcohol Rev* **26**:557–66.

Ljung GM, Box GEP. (1978) Measure of lack of fit in time-series models. *Biometrika* **65**:297–303.

McDowall D, McCleary R, Meidinger E *et al*. (1980) *Interrupted Time Series Analysis*. London: Sage.

Middleton JC, Hahn RA, Kuzara JL *et al*. (2009) Effectiveness of policies maintaining or restricting days of alcohol sales on excessive alcohol consumption and related harms. *Am J Prev Med* **39**:590–604.

Popova S, Giesbrecht N, Bekmuradov D *et al*. (2009) Hours and days of sale and density of alcohol outlets: impacts on alcohol consumption and damage: a systematic review. *Alcohol Alcoholism* **44**:500–16.

Single EW. (1988) The availability theory of alcohol-related problems. In: Chaudron CD, Wilkinson DA (eds). *Theories on Alcoholism*. Toronto: Addiction Research Foundation, 325–51.

Stockwell T, Gruenewald PJ. (2001) Controls on the physical availability of alcohol. In: Heather N, Peters TJ, Stockwell T (eds). *Alcohol Dependence and Problems*. Edited by New York: Wiley and Sons, 699–719.

Toomey TL, Erickson DJ, Carlin BP *et al*. (2012) The association between density of alcohol establishments and violent crime within urban neighborhoods. *Alcoholism: Clin Exp Res* **36**:1468–73.

U.S. Census Bureau. (2012) *Population Estimates Program*. Washington, DC: U.S. Census Bureau. http://www.census.gov/popest/data/index.html (November 2012, date last accessed).

Wells S, Graham K, Purcell J. (2009) Policy implications of the widespread practice of "pre-drinking" or "pre-gaming" before going to public drinking establishments—are current prevention strategies backfiring? *Addiction* **104**:4–9.

Zhu L, Gorman DM, Horel S. (2004) Alcohol outlet density and violence: a geospatial analysis. *Alcohol Alcoholism* **39**:369–75.