INTRODUCTION

Alcohol intoxication and dependence are implicated in nearly all forms of violence and contribute to the burden of disease due to alcohol (Steele and Southwick, 1985; Hull and Bond, 1986; Bushman and Cooper, 1990; Ito et al., 1996; McClelland and Teplin, 2001; Boles and Miotto, 2003; Hoaken et al., 2003; Heinz et al., 2011). Alcohol-fueled violence generates medical and trauma-related expenses for victims, law enforcement and legal costs, as well as costs to employers and the national economy from lost productivity. Despite the well-documented adverse consequences of alcohol consumption, many governments have increased the hours that licensed premises are allowed to serve alcohol. Reviews suggest that on average, increasing alcohol availability results in greater alcohol-induced violence (Popova et al., 2009; Stockwell and Chikritzhs, 2009). At the same time, other governments have sought to curb alcohol-related violence and the strain it places on the health system and society by reducing the availability of alcohol.

One way of reducing alcohol availability is to restrict the business hours of social premises that are licensed to serve alcohol (e.g. pubs, bars, clubs and restaurants). Although research does not provide unanimous support for this technique, methodologically more rigorous studies have consistently shown that increased business hours are associated with an increased reported incidence of violence (see also Stockwell and Chikritzhs, 2009; Rossow and Norström, 2012). For instance, the Australian city of Newcastle mandated earlier closing times of licensed premises and times after which new patrons could not enter (Jones et al., 2009; Kypri et al., 2011). This strategy was successful in reducing the incidence of alcohol-fueled violence reported in the Newcastle City Center. Similarly, in the Brazilian city of Diadema, restricting formerly unrestricted business hours to 11 p.m. significantly reduced homicides and the number of assaults reported against women (Duailibi et al., 2007).

Although interventions, such as those in Newcastle and Diadema, tend to be successful in reducing the reported incidence of violence in the short-term, the long-term stability of these changes is unclear. During the initial intervention period, the reported incidence of violence may be reduced because residents are motivated to solve the perceived problem with violence that triggered the intervention. It is, therefore, important to establish the relationship between alcohol outlet business hours and the reported incidence of violence outside of an intervention framework. Furthermore, the regions chosen for interventions often have prominent problems with alcohol-fueled violence.

Several studies examined the effects of extending business hours, rather than their restriction. The extension of weekend business hours in the Australian city of Perth was followed by increased reports of violent incidents in and around licensed establishments on weekends (Chikritzhs and Stockwell, 2002). This effect appeared to be mediated by increased consumption of alcohol in the licensed establishments. These results may reflect a different type of intervention effect, whereby residents seek to capitalize on a new-found ‘freedom’ to drink for longer into the night following business hour extensions. Additionally, a study of 18 Norwegian cities that experienced changes in business hours suggested that extending and restricting business hours had symmetrical effects (Rossow and Norström, 2012). Specifically, longer business hours were associated with greater reported assault rates, and shorter business hours with lower assault rates.

The longitudinal intervention research, which we have summarized here, suggests that extending outlet business hours later into the night or into early morning increases the reported incidence of violence (see also Ragnarsdóttir et al., 2002; Newton et al., 2007; for exceptions see Babb, 2007 and Hough et al., 2008). In contrast, restricting outlet business hours by bringing forward closing times reduces the reported incidence of violence (for an exception see Graham et al., 1998). However, it is unclear whether the effects of outlet business hours on violence apply to regions without prominent pre-existing violence problems and outside of the initial intervention period.

Our research addresses this gap by examining naturally existing and long-standing variation in business hours across New York State (NYS). This approach precludes intervention-related motivational factors from affecting the magnitude of the alcohol availability—violence relationship. As far as we...
are aware, the rates of alcohol-fueled violence in NYS have not attracted special intervention efforts. Thus, the present data represent estimates of the effect of violence due to alcohol availability on the burden of disease that are unbiased by intervention efforts. If the effects in cross-sectional and intervention studies converge, this may increase confidence in the validity of the relationship between alcohol outlet business hours and the reported incidence of violence. This research also models the burden of disease of the business hours of social premises licensed to serve alcohol.

Consistent with existing intervention research into the effects of alcohol business hours on violence, we hypothesized that counties with longer outlet business hours would have higher reported rates of violent crime (i.e. aggravated assault, murder, forcible rape and robbery) after controlling for variation in demographic characteristics and alcohol outlet density. We expected alcohol availability only to influence violent crime. We, therefore, included property crime rates to examine the specificity of the effects of outlet business hours on crime. We also separately modeled the burden of disease derived from the effect of alcohol availability on aggravated assault, as this is the most commonly reported form of violence in NYS (NYS DCJS, 2010) and the most studied form of alcohol-fueled violence (e.g. Chikritzhs and Stockwell, 2002; Babb, 2007; Jones et al., 2009; Kypri et al., 2011; Rossow and Norström, 2012).

METHODS

This study utilized the counties of NYS, excluding the five counties of New York City (i.e. Bronx, Brooklyn, New York, Queens and Richmond) (n = 57). New York City was excluded because it may be a potential source of bias because the counties of New York City: (1) have higher violent crime rates (M = 523.98, SD = 204.58) than those outside of New York City (M = 196.22, SD = 104.24), t (4.18) = 3.54, P = 0.022, d = 3.46 and (2) uniformly share the longest outlet business hours per week. NYS was selected for study because the region is the only one we identified for study because the region is the only one we identified for which there is both large variation in alcohol outlet business hours and readily publicly available data on the other variables of interest. Data points from 2009 were obtained for all independent and dependent variables, as well as some covariates. In the cases of racial composition, gender composition and societal age structure, data were estimated from census data for the years 2000 and 2010. Data points for 2009 were estimated using the following formula: Estimate\textsubscript{2009} = Census\textsubscript{2010} − (Census\textsubscript{2010} − Census\textsubscript{2000})/10. A descriptive summary of county characteristics is presented in Table 1.

Design

Linear ordinary least squares regression models were used to predict crime from outlet business hours, over and above the effects of relevant population characteristics and per capita alcohol outlets. We statistically controlled for population density, per capita income, unemployment, racial composition, gender composition, age structure and three types of per capita alcohol outlets (on-premises with alcohol as primary purpose, on-premises with meals as primary purpose and off-premises only). After obtaining coefficients with the regression models, the financial burden of disease of outlet business hours was estimated for the region using cost of crime data (McCullister et al., 2010).

Independent variable

Outlet business hours

Data on outlet business hours were obtained from the NYS Liquor Authority (n.d.). All counties share a uniform opening time during the week (8 a.m.). Business hours consequently index the number of hours after midnight in which licensed alcohol serving establishments may sell alcohol. NYS law stipulates that 30 min after the cease in business occurs, alcohol may not be consumed on premises (Alcoholic Beverage Control Law, 1934). However, it should be noted that outlets are not required to utilize the full business hours available to them. A summary variable for hours open after midnight each week was created. On each night, allowed county business hours ranged from 1 a.m. to 4 a.m. Thus, the number of hours open after midnight each week ranged from 7 to 28; 7 h (n = 5), 8 h (n = 1), 9 h (n = 3), 11 h (n = 2), 13 h (n = 1), 14 h (n = 19), 15 h (n = 1), 21 h (n = 3), 27 h (n = 1), 28 h (n = 19). For reference, all New York City counties allow 28 h of after midnight business per week. Splitting the sample into short business hours (<14 hours per week) and long business hours (≥15 hours per week) did not change the effect of outlet business hours on crime.

Dependent variables

Crime

The rate of violent crimes reported per 100,000 inhabitants in 2009 was obtained from the NYS DCJS (2010). Data on violent crime are broken down into four types based on the Uniform Crime/Incident-Based Reporting methodology. These include murder, forcible rape, aggravated assault and robbery. Based on other available data, violent crime was also broken down into that perpetrated with a firearm (gun crime) and without a firearm (non-gun crime) (NYS DCJS, n.d.). For comparison, the rate of property crimes reported per 100,000 inhabitants in 2009 was obtained from the NYS DCJS (2010).

Table 1. Descriptive summary of covariates for NYS counties

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (10,000 people)</td>
<td>19.54</td>
<td>30.84</td>
<td>0.50</td>
<td>152.20</td>
</tr>
<tr>
<td>Population Density (people per square mile)</td>
<td>363.48</td>
<td>737.48</td>
<td>2.89</td>
<td>4714.13</td>
</tr>
<tr>
<td>Per Capita Income (/1000)</td>
<td>35.85</td>
<td>8.20</td>
<td>25.71</td>
<td>71.73</td>
</tr>
<tr>
<td>Unemployment (%)</td>
<td>8.29</td>
<td>0.94</td>
<td>6.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Proportion White (% White)</td>
<td>89.73</td>
<td>7.21</td>
<td>68.42</td>
<td>97.75</td>
</tr>
<tr>
<td>Gender Composition (males per 100 females)</td>
<td>99.39</td>
<td>5.78</td>
<td>92.60</td>
<td>121.79</td>
</tr>
<tr>
<td>Younger Age Structure (% aged 18 to 34)</td>
<td>21.35</td>
<td>3.81</td>
<td>12.65</td>
<td>39.65</td>
</tr>
<tr>
<td>Restaurants (per 10,000 people)</td>
<td>9.89</td>
<td>4.55</td>
<td>4.30</td>
<td>36.14</td>
</tr>
<tr>
<td>On-premises outlet (per 10,000 people)</td>
<td>2.34</td>
<td>0.93</td>
<td>0.83</td>
<td>4.60</td>
</tr>
<tr>
<td>Off-premises outlet (per 10,000 people)</td>
<td>1.28</td>
<td>0.65</td>
<td>0.00</td>
<td>4.06</td>
</tr>
</tbody>
</table>

Note: population is not a covariate used in the analyses, but was used to calculate population density.
Covariates

Per capita alcohol outlets

Businesses with the main function of selling alcohol can be licensed for on-premises consumption, off-premises consumption or both. We calculated the number of businesses licensed for on-premises alcohol consumption, such as bars, taverns and nightclubs, per 10,000 people (US Census Bureau, 2009a). Additionally, we calculated the number of businesses licensed for only sales of packaged alcohol for off-premises consumption per 10,000 people (US Census Bureau, 2009b). Furthermore, some businesses with other primary functions, such as service of meals, may also be licensed to serve alcohol. One such common type of business is a full-service restaurant. As such, we calculated the number of full-service restaurants per 10,000 people (US Census Bureau, 2009c). This measure also served as a proxy for the size of a county’s night-time economy.

Unemployment and per capita income

Unemployment rates (NYS Department of Labor, n.d.) and per capita income in $1000 intervals (Empire State Development, n.d.) are both important covariates as lower rates when controlling for per capita alcohol per capita income, unemployment, outlets population density, racial composition, gender composition and age structure. The descriptive crime statistics and parameter estimates from the regression models are presented in Table 2 for violent and property crimes as well as gun and non-gun violent crimes. Table 3 shows the subtypes of violent crimes. As a sensitivity analysis, each regression was repeated with any multivariate outliers removed. Outliers were defined as cases with standardized residuals >3.00. All outliers, and any effects that changed with their removal, are noted in Tables 2 and 3. Only the effects that were consistent before and after the removal of outliers were considered robust and are discussed in text.

As hypothesized, significant positive relationships were identified between outlet business hours and the reported incidence of violent crime generally, as well as aggravated

<table>
<thead>
<tr>
<th>Variable</th>
<th>Violent crime</th>
<th>Property crime</th>
<th>Gun crime</th>
<th>Non-gun crime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Density</td>
<td>−48.27</td>
<td>−77.25</td>
<td>6.94</td>
<td>−55.34</td>
</tr>
<tr>
<td>Per Capita Income</td>
<td>−6.09</td>
<td>−57.59</td>
<td>−2.14</td>
<td>−3.95</td>
</tr>
<tr>
<td>Unemployment</td>
<td>8.15</td>
<td>21.02</td>
<td>−1.76</td>
<td>9.85</td>
</tr>
<tr>
<td>Proportion White</td>
<td>−14.13</td>
<td>−68.59</td>
<td>−3.32</td>
<td>−10.82</td>
</tr>
<tr>
<td>Gender Composition</td>
<td>−8.70</td>
<td>−59.27</td>
<td>−1.44</td>
<td>−7.26</td>
</tr>
<tr>
<td>Younger Age Structure</td>
<td>−2.11</td>
<td>−13.23</td>
<td>−1.60</td>
<td>0.38</td>
</tr>
<tr>
<td>Restaurants</td>
<td>−5.78</td>
<td>−11.07</td>
<td>−0.60</td>
<td>−5.18</td>
</tr>
<tr>
<td>Off-premises outlet</td>
<td>34.20</td>
<td>7.19</td>
<td>4.79</td>
<td>29.39</td>
</tr>
<tr>
<td>Business Hours</td>
<td>4.76</td>
<td>11.23</td>
<td>0.58</td>
<td>4.18</td>
</tr>
</tbody>
</table>

Note: in the violent crime model $R^2 = 0.68$ ($P < 0.001$), and there were no outliers; in the property crime model $R^2 = 0.56$ ($P < 0.001$), and there were no outliers; in the gun crime model $R^2 = 0.58$ ($P < 0.001$), and the county of Erie was an outlier (standardized residual = 3.72). When Erie was excluded, the patterns of significance did not change; in the non-gun crime model $R^2 = 0.66$ for Step 1 ($P < 0.001$), and there were no outliers.

RESULTS

All covariates were mean-centered for use in the linear regression models. So that regression coefficients at values of zero on all parameters were meaningful, outlet business hours were set to a minimum of zero, such that a county with 7 outlet business hours after midnight (i.e. 1 a.m. across the week) had a value of 0 and a county with 28 outlet business hours (i.e. 4 a.m. across the week) after midnight had a value of 21.
assault and non-gun violent crime specifically. Alcohol outlet business hours were unrelated to property crime. Every 1 h increase in weekly outlet business hours was significantly associated with 4.75 more reported violent crimes per 100,000 people (95% confidence interval (CI): 1.71–7.80, t(46) = 3.15, P = 0.003), 4.18 more reported non-gun crimes per 100,000 people (95% CI: 1.72–6.65, t(46) = 3.42, P = 0.001) and 3.34 more reported aggravated assaults per 100,000 people (95% CI: 1.24–5.44, t(46) = 3.20, P = 0.002). The effects of outlet business hours on violent crime, non-gun crime and aggravated assaults were significant over and above the significant effects of on-premises outlet density.

The increased reported incidence of violent crime (with the exception of murder and forcible rape) and property crime were also associated with lower per capita income, more non-White residents and a greater proportion of women. Of these variables, murder was associated only with more non-White residents, while forcible rape was not associated with any. Furthermore, per capita restaurants were associated with lower reported rates of non-gun crime. Per capita off-premises outlets, societal age structure and population density were not related to the reported incidence of any type of crime.

Supplementary analyses
We conducted two further sets of tests to confirm the robustness of the results. First, the analyses were repeated with aggregate crime rate data for a 5-year period from 2007 to 2011. This analysis can account for the possibility of reporting inaccuracy in smaller counties. Secondly, all analyses except gun and non-gun crime were repeated with the five counties of New York City included (i.e. Bronx, Brooklyn, New York, Queens and Richmond). Gun and non-gun crime data were not available at county level for New York City. These analyses consistently replicated the primary findings that longer business hours and greater on-premises outlet density were associated with elevated violent crime, non-gun crime and assaults. (Full results of these analyses are available from the first author upon request.)

Burden of disease
Longer outlet business hours were associated with a greater reported incidence of aggravated assaults for every hour that business could occur beyond 1 a.m. during the week. Considering that in the counties with the latest opening times, establishments are open for a further 21 h per week, we modeled the financial costs for up to 21 extra business hours per week.

Aggravated assault incurs financial burdens across multiple domains. These encompass costs to the victim including medical expenses, the criminal justice system and the lost productivity resulting from time spent engaging in criminal behavior. McCollister et al. (2010) estimated the costs of aggravated assault at $8700 to the victim, $8641 to the criminal justice system and $2126 for lost productivity. Furthermore, the cost of associated pain-and-suffering was estimated to be $13,435. Thus, the financial burden of one aggravated assault was estimated at $32,972.

Based on the regression parameters for aggravated assault (Table 3), the predicted assault rate (per 100,000 people) was generated for each county:

\[
\text{Predicted assault rate} = 95.39 + \text{Density} \times -38.68 + \text{Income} \times -3.74 + \text{Unemployment} \times 10.34 + \text{Proportion White} \times -8.11 + \text{Gender Composition} \times -4.86 + \text{Age structure} \times -0.42 + \text{On premises outlets} \times 22.36 + \text{Off premises outlets} \times 1.51 + \text{Restaurants} \times -3.25 + \text{Outlet business hours} \times 3.34.
\]

The predicted assault rate (per 100,000 people) was subsequently converted into a predicted number of assaults per county because modeling the burden of disease required the frequency of crime, rather than its rate. The predicted number of assaults correlated strongly with the actual number of reported assaults per county in 2009 (r = 0.76,
Using predicted assaults allowed the CI around outlet business hours to be used to generate upper and lower bounds for the alcohol-violence burden of disease estimates (lower = 1.24 and upper = 5.44). The sum of the predicted number of assaults across included counties was 17,456 (95% CI: 13,756–21,156; actual frequency = 16,885), which is equivalent to a $575.5 million burden of disease (actual frequency = $556.7 million). The predicted number of assaults provided numerical estimates similar to those from the actual frequency.

We also modeled the predicted number of assaults if outlet business hours were restricted until 1 a.m. on each night of the week in each county. Weighted by the number of people in each county, this would be equivalent to a 2.3 h reduction in outlet business hours per day in NYS. The sum of the predicted number of assaults after this reduction in daily business hours would be 11,572, representing 33.7% fewer assaults over the initial predicted values (95% CI: 15.9–45.3%). Thus, the burden of disease from having licensed premises open after 1 a.m. was estimated at $194.0 million for the state of New York, excluding New York City (95% CI: $91.4–$260.8 million).

**DISCUSSION**

Longer on-premises alcohol business hours were associated with an increased reported incidence of aggravated assaults and violence perpetrated without a firearm. Within the relatively small region of NYS, the cost of assaults associated with business hours beyond 1 a.m. was $194.0 million. However, this is likely to be an underestimate because the burden of disease modeling did not include New York City, which has much higher crime rate and population than the rest of NYS (NYS DCJS, n.d.). Our findings suggest that the assaults associated with longer business hours are not attributable to a general increase in crime rates, as property crime was unrelated to business hours. Furthermore, our study utilized a non-intervention approach. Thus, the data suggest that the effect of alcohol availability is present outside of the initial change periods typically studied in intervention designs. Moreover, these findings may generalize to areas not known for having prominent problems with alcohol-fueled violence (such as NYS).

The effects of alcohol outlet business hours on reported violence, non-gun crime and aggravated assault were present despite controlling for the density of on-premises licensed alcohol outlets. Consistent with prior research, our findings suggest that the density of on-premises outlets offering alcohol as a primary rather than secondary service is a positive predictor of assault (Livingston, 2011). However, unlike Livingston (2011), we did not find a relationship between off-premises licenses and assault. One reason for this discrepancy may be that Livingston (2011) utilized assault hospitalizations rather than assaults reported to police, which we examined. Perhaps individuals involved in assaults linked to off-premises consumption, and thus probably to private drinking contexts, are more likely to directly present to hospitals rather than police.

Three additional factors predicted the incidence of reported crime broadly, including rates of aggravated assault. Lower per capita income was associated with higher reported crime rates. This may reflect greater potential gain from criminal behavior or greater stress (Ehrlich, 1973). Counties with a greater proportion of non-White residents had higher crime rates. Finally, despite males being more likely to be incarcerated than females (West and Sabol, 2009), a greater number of females were associated with higher crime rates. While this may seem counterintuitive, a greater number of females may reflect higher rates of incarceration among males in that county, and thus a greater likelihood of criminal trajectory. In addition to these broad predictors, the lower rates of reported non-gun crime in regions with higher per capita restaurants may reflect a buffering effect of a more accessible non-alcohol focused nightlife.

A novel feature of the present research is that the region of study was not selected based on pre-existing concerns about alcohol-fueled violence in the community. As such, our findings demonstrate that the relationship between outlet business hours and the reported incidence of violent crime, as identified in the existing intervention literature, generalizes beyond regions with existing concerns about alcohol-fueled violence and those with a ‘new-found freedom’ to drink longer. The magnitude of the business hour-assault effect is also of a size comparable with those in past studies such as the 16.0% per hour in Norway (Rossow and Norström, 2012) and the 18.5% per hour in Newcastle (Jones et al., 2009; Kypri et al., 2011). Although the causal direction cannot be ascertained from the present design, past longitudinal research strongly suggests that longer alcohol outlet business hours cause an increase in the reported incidence of violence, while shorter business hours attenuate this violence (e.g. Rossow and Norström, 2012).

One limitation is that we could not determine whether businesses actually took up their allowed business hours. If there was a shortfall in hour uptake, but it was uniformly distributed across early and late allowance counties, then the modeling should be accurate. However, if there was a shortfall in hour uptake that is not uniform, the effects may be either underestimates or overestimates. Specifically, if the shortfall in hour uptake is greatest in counties allowing longer business hours, then we likely underestimated the magnitude of the effect and the burden of disease. In contrast, if the shortfall in hour uptake is greatest in counties allowing shorter business hours, then we likely overestimated the magnitude of the effect and the burden of disease.

The present data relied on police reports, which may be affected more by willingness to report rather than actual crime rates. If this was the case, then it may be expected that outlet business hours would also affect reported rapes, as rape is thought to be the most underreported type of crime (Kelly et al., 2005). Although we did not find any evidence for this, it is possible that outlet business hours only affected willingness to report assaults. An alternative and quite likely possibility is that when outlet opening hours are shorter, the location of assaults may shift from a public context to a private context such as the home. It is likely that assaults in public places (e.g. bars in city centers) are more likely to be reported to police than assaults in private locations (e.g. suburban homes). Future research into the effects of alcohol outlet business hours on violence could consider this type of possible spatial displacement. For instance, the relationship of alcohol outlet business hours with domestic violence should be examined to ensure that shorter opening hours do...
not have the unintended side-effect of increasing domestic violence.

Intervention studies show that shorter business hours for alcohol serving establishments reduce alcohol-related harm, and we have shown that this is not limited to regions with overt alcohol and violence problems during intervention periods. Moreover, other pro-active strategies such as community-level alcohol intervention programs can reduce both alcohol-related harm and the number of emergency room visits required for alcohol-related harm (Cherpitel, 1993; Holder et al., 2000). Thought should thus be given to whether reducing alcohol consumption at the community level, potentially through pushing for changes in business hours, will be an effective strategy for reducing alcohol-related harm and the strain placed on hospital emergency rooms and society.

Conclusions
Longer hours of alcohol service were associated with higher reported rates of aggravated assaults and violence perpetrated without a gun. This relationship appears to be responsible for a large financial burden of disease in NYS. The cost of aggravated assaults alone was estimated at $194.0 million in 2009. Given that this previously identified relationship generalized to a location without major alcohol-related violence problems, it is worth considering widespread interventions into outlet business hours to restrict the availability of alcohol. Doing so is likely to reduce societal harm, financial costs and the strain on hospital emergency rooms by lowering intake of assault victims.

Funding — This research was supported by Project Grant 630671 from Australia’s National Health and Medical Research Council.

Conflict of interest statement. None declared.

REFERENCES
Alcoholic Beverage Control Law of 1934. New York State, USA.