Accident Analysis and Prevention 55 (2013) 135–143

Contents lists available at SciVerse ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Spatial panel analyses of alcohol outlets and motor vehicle crashes in California: 1999–2008

William R. Ponicki*, Paul J. Gruenewald, Lillian G. Remer

Prevention Research Center, Pacific Institute for Research & Evaluation, 1995 University Avenue, Suite 450, Berkeley, CA 94704, United States

ARTICLE INFO

Article history:
Received 11 July 2012
Received in revised form 9 October 2012
Accepted 1 March 2013

Keywords:
Alcohol availability
Alcohol outlet density
Motor vehicle crashes
Spatial analysis

ABSTRACT

Although past research has linked alcohol outlet density to higher rates of drinking and many related social problems, there is conflicting evidence of density's association with traffic crashes. An abundance of local alcohol outlets simultaneously encourages drinking and reduces driving distances required to obtain alcohol, leading to an indeterminate expected impact on alcohol-involved crash risk. This study separately investigates the effects of outlet density on (1) the risk of injury crashes relative to population and (2) the likelihood that any given crash is alcohol-involved, as indicated by police reports and single-vehicle nighttime status of crashes. Alcohol outlet density effects are estimated using Bayesian misalignment Poisson analyses of all California ZIP codes over the years 1999–2008. These misalignment models allow panel analysis of ZIP-code data despite frequent redefinition of postal-code boundaries, while also controlling for overdispersion and the effects of spatial autocorrelation. Because models control for overall retail density, estimated alcohol-outlet associations represent the extra effect of retail establishments selling alcohol. The results indicate a number of statistically well-supported associations between retail density and crash behavior, but the implied effects on crash risks are relatively small. Alcohol-serving restaurants have a greater impact on overall crash risks than on the likelihood that those crashes involve alcohol, whereas bars primarily affect the odds that crashes are alcohol-involved. Off-premise outlet density is negatively associated with risks of both crashes and alcohol involvement, while the presence of a tribal casino in a ZIP code is linked to higher odds of police-reported drinking involvement. Alcohol outlets in a given area are found to influence crash risks both locally and in adjacent ZIP codes, and significant spatial autocorrelation also suggests important relationships across geographical units. These results suggest that each type of alcohol outlet can have differing impacts on risks of crashing as well as the alcohol involvement of those crashes.

1. Introduction

Alcohol-related traffic crashes are a major problem in the United States, resulting in more than 10,000 fatalities in 2010 and imposing annual costs of $37 billion (NHTSA, 2012). Although alcohol involvement rates among traffic crashes declined sharply during the 1980s and early 1990s, drinking has consistently been associated with roughly one third of crash fatalities since 1995 (IIHS, 2005, 2011). One strategy for reducing alcohol-involved traffic crashes is to impose limitations on the physical availability of alcohol, which many studies indicate can reduce drinking and related problems (reviewed in Gruenewald, 2011). Limiting alcohol outlets in an area is theorized to increase the convenience cost of obtaining beverages and thus reduce alcohol demand and drinking-related problems (Chaloupka et al., 1998). Some authors have argued that reductions in alcohol availability may be less effective at reducing motor vehicle crashes than other drinking problems because increased driving distances to obtain alcohol may outweigh any reduction in average drinking (McCarthy, 2003; Lapham et al., 1998; Gary et al., 2003; Gruenewald et al., 2002).

1.1. Prior empirical research

Previous studies have produced inconsistent findings regarding the relationship between alcohol availability in an area and the local risks of alcohol-involved crashes. A majority of analyses have suggested a positive relationship between alcohol availability and crash risks, particularly for bar density (Scribner et al., 1994; Jewell and Brown, 1995; Gruenewald et al., 1996; Escobedo and Ortiz, 2002; McCarthy, 2003, 2005; Farmer et al., 2005; Treno et al., 2007). Cotti and Walker (2010) found vehicle crash risks to be positively related to the presence of tribal casinos, which typically include beverage service and tend to draw more customers than do typical alcohol outlets. Other studies, however, have estimated a negative

* Corresponding author. Tel.: +1 510 883 5713; fax: +1 510 644 0594.
E-mail addresses: bponicki@prev.org, ponicki@yahoo.com (W.R. Ponicki).

0001-4575/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.aap.2013.03.001

relationship between alcohol availability and crashes (McCarthy, 2003 for off-premise density; Baughman et al., 2001; Treno et al., 2007 for restaurant density).

Past studies take varying approaches to measuring the impacts of alcohol availability on crashes, and these will affect the interpretation of their results. Several studies examine only the effect of categorical legal bans on alcohol sales within a jurisdiction (e.g., dry counties; Baughman et al., 2001; Gary et al., 2003), providing less guidance about adding outlets in the majority of areas that allow alcohol sales. Other analyses measure continuous outlet-density effects at the county level (Jewell and Brown, 1995; Kelleher et al., 1996), but alcohol retail concentrations averaged across such large geographic areas may not accurately reflect ease of access at the local level. This lack of geographic resolution potentially biases effect estimates toward zero. Other studies have measured outlet density effects on crashes in California at finer spatial resolution such as cities (Scribner et al., 1994; McCarthy, 2003; Farmer et al., 2005) or postal codes with stable populations (Treno et al., 2007). The smaller spatial units allow these analyses to measure outlet density more accurately, but their restricted geographic samples (excluding rural areas or regions with rapid population growth) may not be representative of the entire state.

1.2. Spatial scale

The spatial scale of the hypothesized relationship between alcohol outlet density and crashes is not clear. Customers may drive a long or short distance to obtain alcohol. Large geographic areas such as counties are more likely to contain both the outlet and the crash location, but the county-wide outlet density may not reflect the local accessibility of alcohol to any given resident. Outlet density measures will be more relevant in smaller spatial units such as cities or postal codes, but at this scale customers are more likely to cross into nearby areas to obtain alcohol. Some previous studies have included both local and adjacent-area outlet density measures in order to allow for such cross-border effects (Jewell and Brown, 1995; Treno et al., 2007).

1.3. Biased statistical tests

Standard regression methods assume that model residuals are independent across all observations, and a failure of this independence can bias analyses toward finding significant effects. This assumption of independence is generally violated in spatial data, where neighboring areas tend to be similar in ways that cannot be completely explained by model covariates. Gruenewald et al. (1996) and Treno et al. (2007) found a high degree of spatial autocorrelation in their analyses relating traffic crashes to alcohol outlet densities and used statistical methods to control for it. Other analyses in this literature have failed to account for spatial autocorrelation, however, and may therefore be substantially biased.

1.4. Study outline

The goal of this study is to provide improved estimates of the relationship between alcohol outlet density and injury crashes. It analyzes a panel data set for the State of California that is larger and more spatially-resolved than has been used in prior studies, with over 1600 statewide ZIP codes over the years 1999–2008 (n = 16,712). Because high outlet density has been hypothesized to increase drinking but possibly reduce driving distances, we separately assess the impacts of alcohol availability on population crash risks and the likelihood that those crashes are alcohol-involved. Unlike most prior studies, these analyses measure the effects of various types of alcohol outlets while controlling for general retail density, helping to differentiate the effect of a bars or liquor stores from establishments that do not sell alcohol. These outlet density relationships with injury crashes are estimated both within a geographical area and between adjacent ZIP codes. These models are designed to investigate two hypotheses: (1) greater numbers of injury crashes relative to population will occur in association with greater densities of retail establishments in general (which attract traffic into an area) and of alcohol establishments in particular and (2) greater proportions of injury crashes will be alcohol related in areas with greater densities of bars. The second hypothesis is tested using crashes in two alcohol-related categories: those for which police noted a driver who had been drinking (HBD, which has shown high validity as a measure of impaired driving; McCarty et al., 2009), and single-vehicle nighttime (SVN) collisions (a common impaired-driving surrogate that has been shown to be highly alcohol-involved; Voas et al., 2009). All models control for the effects of local demographic and economic characteristics as well as residual spatial autocorrelation.

2. Material and methods

We collected data on motor vehicle crashes, alcohol retail outlets, and other variables throughout California for the years 1999–2008. Although crashes and alcohol outlets are located at specific points, they were aggregated to the ZIP code level for purposes of these analyses. ZIP codes have high geographic resolution in urban areas and are the finest available level of resolution for some archival data sets. These units entail significant disadvantages, however, as they do not align closely with community or political boundaries and the number of units as well as individual boundaries change over time.

2.1. ZIP code definitions

ZIP codes are collections of routes, defined by the US Postal Service to expedite the delivery of mail, and as such are frequently altered to meet postal needs. Statewide counts of ZIP codes increased from 1645 to 1693 during the study period. Geographic Data Technologies (and successors TeleAtlas and TomTom) create regularly updated ZIP code polygon files based on postal route data and interpolating on topology and roadway connectivity to ensure complete polygon coverage of the state (annual files obtained from Claritas, Inc., 2002, and ESRI, 2010). ZIP codes defined strictly for post office boxes or for a single building were merged into surrounding polygons to create a working ZIP code polygon file for each year. Geocoded data such as crash locations and alcohol outlet addresses were then aggregated to these year-specific polygon files.

2.2. Injury crash data

Individual-level data on traffic crashes within California for the years 1999–2008 were obtained from the California Highway Patrol's (CHP) Statewide Integrated Traffic Records System (SWITRS). This system combines crash data from all local law-enforcement jurisdictions in the state. Only crashes involving an injury or death were selected for these analyses because property damage only crash data is inconsistently collected. State law requires that all crashes involving any injury or death be reported to the CHP, either directly or via local police agencies (California Vehicle Code Section 20008). The SWITRS crash data is widely used in the literature (Scribner et al., 1994; McCarthy, 2003; Treno et al., 2007). Supplementary analyses including property-damage-only crashes produced similar results (not shown). Crash locations were geocoded to ZIP codes in three phases. First, nearly 100% of SWITRS records listing highway post-miles were geocoded by the University of California's Safe Transportation Resource and Education