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Alcohol and non-alcohol-related motor vehicle crashes in Perth, Australia: Do alcohol outlets make a difference?

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ABSTRACT

This study examined the effects of distance from alcohol outlets to motor vehicle crashes across the Perth metropolitan area. A retrospective population-based study was undertaken using measures of alcohol- and non-alcohol-related crashes, and their proximity to alcohol outlets, using a geographic information system. Two logistic regression models were developed with the following outcomes: i) crashes including drivers with BAC ≥ 0.05%, and ii) weekend single vehicle night-time crashes, a surrogate measure of alcohol-related crashes. The surrogate measures of non-alcohol-related crashes for these models were all day-time and single vehicle day-time crashes respectively. The major predictors of alcohol-related crashes were number of on-premise outlets and bottleshops in buffer zones up to 2 km, 2 km–5 km, 5 km–10 km and 10 km-20 km from crashes. The distance from the central business district (CBD) and sociodemographic factors were controlled for. The study included 341,467 crashes that occurred between 2005 and 2015. The highest crash incidence rates occurred in the CBD. The statistical models indicated that crashes with a higher number of on-premise outlets in adjacent buffer zones were more likely to be alcohol-related than non-alcohol-related crashes. Crashes with a higher number of on-premise outlets less than 2 km, 2 km–5 km, 5 km–10 km, and 10 km–20 km from the crashes were significantly more likely to be weekend single vehicle night-time crashes than day-time crashes (OR = 1.014; 95% CI:1.002-1.027, OR = 1.022; 95% CI:1.014-1.029, OR = 1.019; 95% CI:1.014-1.024, and OR = 1.017; 95% CI:1.014-1.020 respectively). There was some evidence that crashes with lower number of bottleshops in adjacent buffer zones were more likely to be alcohol-related crashes, although this was not consistent across both models and all buffer zones. When other predictors were controlled for, alcohol-related crashes were more likely to occur further from the CBD, than in the CBD. Recommendations about the timing and location of roadside alcohol testing are made.

1. Introduction

A body of research over the last 90 years has established that alcohol has a negative effect on cognition, performance and behaviour. The short-term physiological effects of alcohol include decreased motor coordination, impaired attention, perception and judgement (Cherpitel, 1992), all of which have the potential to lead to poor driving and increased risk of a crash. As a result, a large body of research has developed, studying the effects of alcohol on drivers, and crash rates.

From the 1930s onwards, research has consistently found an association between drink-driving and motor vehicle crashes (Miles et al., 1933; Holcomb, 1938; McCarroll and Haddon Jr, 1962). The Grand Rapids study explored the dose response between blood alcohol concentration (BAC) and risk of motor vehicle crash involvement, showing a rapid increased risk of crash involvement in drivers with BACs greater than 0.08%, and extremely high risk of crash involvement at BACs greater than 0.15% (Borkenstein et al., 1974). Previous research has also concluded that there is strong evidence that some driving-related skills (including divided attention and information processing tasks) are impaired even at very low BACs (Moskowitz et al., 1985; Moskowitz, 1989; Moskowitz and Fiorentino, 2000).

Alcohol outlet density is defined as the number of alcohol outlets within a defined geographical region, standardised by residential population or land area (Chikritzhs et al., 2007) and is a measure of the physical availability of alcohol to consumers. Availability theory proposes that increased availability of alcohol leads to increased alcohol consumption resulting in increased harms (Single, 1988). Stockwell and Gruenewald developed this theory further to include the question of the 'full price' of alcohol (which includes the distance travelled to acquire it) and 'routine drinking activities' (where, when and with whom alcohol is consumed) (Stockwell and Gruenewald 2003) Previous research has examined the effects of alcohol availability on various

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alcohol-related harms including road crashes and injury (Gruenewald and Ponicki 1995; LaScala et al., 2001; Gruenewald 2010;Cameron et al., 2012). The findings have been mixed, with motor vehicle crash studies showing varying results, depending on the alcohol outlet type examined [on-premise outlets or bottleshops (e.g., McCarthy, 2003; Cameron, 2012; Hobday et al., 2016)].

One of the reasons for the widely varying conclusions is the use of different geographic units (such as states, postcodes and census tracts) across the studies. One recent methodology used to overcome the limitations of administrative geographic units is buffer zones, or distance bands, around motor vehicle crashes to analyse the associations between alcohol outlets and alcohol-related harms. Alternate methods of measuring proximity of alcohol outlets to alcohol-related harms include distance to the nearest outlet (Hay et al., 2009; Wilkinson and Livingston, 2012; Young et al., 2013) and mean distance to the closest five outlets (Donnelly et al., 2006). The latter methods of measuring proximity to alcohol outlets have not generally been used in road safety research.

Motor vehicle crashes differ from other alcohol-related harms because the risk of a crash is affected by both alcohol availability and driving exposure. Greater alcohol availability (Smart, 1980) is associated with easier access to closer outlets, and potential for greater alcohol consumption (Stockwell and Gruenewald, 2003), resulting higher BACs and an increased risk of a motor vehicle crash. Crash risk is also affected by driving exposure levels: more distant (less “available”) alcohol outlets require driving greater distances to and from the outlets (Tang, 2013), involve increased exposure to driving, and higher risk of a motor vehicle crash (Cameron, 2012)

By using the number of alcohol outlets in several buffer zones to measure alcohol availability, this study aimed to explore the association between the distance between on-premise outlets and bottleshops, and alcohol-related motor vehicle crashes, in metropolitan Perth, Western Australia. A surrogate measure of alcohol-related crashes was included for comparison purposes, as BAC is not recorded for every driver involved in every crash.

2. Materials and methods

A longitudinal retrospective population study was undertaken. The study area was the Perth Greater Capital City Statistical Area as defined by the Australian Bureau of Statistics – ABS (2011).

2.1. Data sources

Alcohol outlet licensing information was acquired from the Department of Racing, Gaming and Liquor Western Australia for each year from 2005 to 2015. The following information was obtained from 2005 to 2015: the name of each alcohol outlet; the physical address (full street address which is necessary for geocoding); the licence type (for example, bottleshop or nightclub) and the years that the alcohol outlet was active. The street addresses were then batch geocoded using an online geocoding application, mappify (2016). Alcohol outlets which could not be located in mappify were individually geocoded using Google Maps.

The crash data was extracted from the Integrated Road Information System (IRIS) database, which is maintained by Main Roads Western Australia, for the period 1 January 2005 to 31 December 2015. Unit record information was acquired for each ‘vehicle controller’ (e.g., driver, rider) related in each crash, including: the crash number (referred to as ‘accident number’ in the IRIS database); their sex, age and road user type (e.g., driver of a car, motorcycle rider); date; time; location (including longitude and latitude of the crash); and the nature and circumstance of a crash, including blood alcohol concentration (BAC) where recorded. Only the driver crash records or motorcycle rider crash details were included. BAC data on passengers or other road users was not used to identify BAC ≥ 0.05% crashes. A single crash record was retained for each crash, including the BAC on any drivers involved in the crash.

2.2. Surrogate measures of alcohol-related and non-alcohol-related crashes

A highly specific and sensitive surrogate measure of alcohol-involvement, weekend single vehicle night-time crashes between 18h00 to 04h59, was also used as an alternate measure of alcohol-related crashes. All crashes occurring during this time period were included in this surrogate measure, regardless of BAC status of any drivers. This surrogate measure was formulated based on previous road safety research in Australia (Chikritzhs et al., 2000; Briscoe, 2004) and internationally (Heeren et al., 1985; Hingson et al., 1987; Voas et al., 2009), and on examination of the temporal patterns of Perth crashes over the study period. Two surrogate measures of non-alcohol-related crashes were defined: all day-time crashes, and single vehicle day-time crashes (from 07h00 to 17h59). All relevant crashes included in this time period were included, regardless of the BAC status of any drivers.

2.3. Geographic information system analysis

Individual maps were created for each year using a geographic information system or GIS (ArcGIS 10.4 – ESRI, 2015) with postal areas [the ABS approximation of postcodes (ABS, 2012)] used as the administrative boundaries. Greater Perth postcodes were grouped according to their distance from the central business district (CBD) into four categories or zones (Map 1) based on previous research in Perth (Luk et al., 2009, Hobday et al., 2016). The average road links (the distance between traffic signals) for each zone are indicated below:

- i *CBD*: the road links were approximately 300 m or less.
- ii *Inner zone*: road links approximately between 300 m and 1,000 m. Perth postcodes within 7 km of the city centre but outside the CBD were included in the category.
- iii *Middle zone*: road links approximately between 1,000 m and 1.5 km. The postcodes included were between 7 km and 15 km from the CBD.
- iv *Outer zone*: road links on average greater than 1.5 km. The postcodes were more than 15 km from the CBD.

The road network distances between licensed outlets and each crash were measured using the GIS so that alcohol outlets could be allocated to buffer zones. Four buffer zones were created: number of alcohol outlets up to 2km, 2 km up to 5 km, 5 km up to 10 km and 10 km up to 20 km from crashes. Each buffer zone was created separately for on-premise outlets (where outlets primarily sell alcohol for on-site consumption, such as hotels/taverns, restaurants and nightclubs) or off-premise outlets [referred to in this paper as bottleshops, which sell alcohol purely for off-site consumption (Trifonoff et al., 2011)]

2.4. Statistical analysis

Descriptive statistics were undertaken. Data on motor vehicle crashes, the number of on-premise outlets and bottleshops in each buffer zone, distance from the CBD (i.e., zone from the CBD), and postcode-level socio-economic and demographic information from the ABS were merged. Two multiple logistic regression models were undertaken with: i) confirmed alcohol-related crashes and ii) weekend single vehicle night-time crashes as the primary outcome variable for each model.

For model i), the outcome variable was confirmed alcohol-related crashes (BAC ≥ 0.05%), compared to the surrogate measure of non-alcohol-related crashes: all day-time crashes (07h00 to 17h59).

For model ii) the main outcome variable was the surrogate measure of alcohol-related crashes, all weekend single vehicle night-time (SVN – 18h00 to 04h59) crashes, compared to the alternate surrogate measures on non-alcohol-related crashes: single-vehicle day-time crashes (07h00