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Proximity of off-premise alcohol outlets and heavy alcohol consumption: A cohort study☆

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ABSTRACT

Background: Availability of alcohol has been associated with alcohol consumption in cross-sectional studies. We examined longitudinally whether change in proximity to off-premise (i.e., no consumption on the premises) beer and liquor outlets is associated with heavy alcohol consumption.
Methods: Distances from 54,778 Finnish Public Sector study participants' homes to the nearest off-premise beer and liquor outlets were calculated using Global Positioning System-coordinates. Between-individual analyses were used to study the effects of distance to the nearest outlet on heavy alcohol use, and within-individual analyses to study the effects of a *change* in distance on *change* in heavy use.
Results: Mean follow-up time in 2000–2009 was 6.8 (standard deviation 2.0) years. In a between-individual analysis, decrease from ≥500 m to <500 m (vs. remained ≥500 m) in the distance to the nearest beer outlet increased the likelihood of incident heavy alcohol use in women (odds ratio 1.23, 95% CI 1.05–1.44), but not in men. In a within-individual analysis decrease from 500 m to 0 m in log-transformed continuous distance to the nearest beer outlet increased the odds of heavy alcohol consumption in women by 13% (odds ratio 1.13, 95% CI 1.01–1.27). For the corresponding change in distance to liquor outlet the increase was 3% (odds ratio 1.03, 95% CI 0.97–1.09).
Conclusions: Change in distance from home to the nearest off-premise alcohol outlet affects the risk of heavy alcohol consumption in women. This evidence supports policies that restrict physical availability of alcohol.

1. Introduction

Heavy alcohol use is a worldwide public health problem with an important contribution to the burden of illnesses (Gronbaek, 2009; Rehm et al., 2009); among 15- to 44-year-old men, more than every fifth death in the European and American WHO regions is related to alcohol use (WHO, 2011). The economic costs of excessive alcohol use are also remarkable, in the U.S., for example, the estimated costs in 2006 were $223.5 billion (Bouchery et al., 2011).

Studies have suggested that availability, as indicated by density of alcohol outlets within towns, zip code areas and census tracts (Campbell et al., 2009; Livingston et al., 2008; Popova et al., 2009; Schonlau et al., 2008; Treno et al., 2003) and other geographical areas (Connor et al., 2011; Kavanagh et al., 2011; Paschall et al., 2012; Stockwell et al., 2011), or distance from home to an alcohol outlet (Picone et al., 2010; Pollack et al., 2005; Scribner et al., 2000) is associated with alcohol consumption. Findings especially for the associations between off-premise outlets and heavy alcohol consumption have been mixed; studies using density measures have reported positive associations (Campbell et al., 2009; Connor et al., 2011; Kavanagh et al., 2011; Livingston et al., 2008), whereas associations for distance measures have not been found (Kavanagh et al., 2011; Truong and Sturm, 2007). However, prior research on alcohol availability has often been limited by cross-sectional designs (Connor et al., 2011; Kavanagh et al., 2011; Livingston et al., 2008; Paschall et al., 2012; Pollack et al., 2005; Schonlau et al., 2008; Scribner et al., 2000; Treno et al., 2003; Truong and Sturm, 2007) or the use of alcohol sales, instead of self-reported consumption data (Campbell et al., 2009). Further, density as the measure of availability within large administrative areas (Livingston et al., 2008; Popova et al., 2009; Schonlau et al., 2008; Stockwell et al.,

☆ Supplementary material can be found by accessing the online version of this paper. Please see Appendix A for more information.

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2011; Treno et al., 2003) may provide unequal estimates for those living in the center versus the periphery of the area. We have shown that a change in distance to an on-site alcohol outlet ("a bar") is associated with a change in heavy drinking (Halonen et al., 2013), and want therefore examine whether the same is true for off-premise outlets (i.e., liquor outlets, grocery and convenience stores, and gas stations selling alcohol for consumption off-premises) that are more abundant. The answer would potentially inform about directions to which alcohol outlet policies should be developed.

In this study, the effect of proximity of an off-premise alcohol outlet (i.e., no consumption on the premises) on heavy alcohol consumption was longitudinally examined in a large adult sample. The aim was to determine whether distance to the nearest off-premise alcohol outlet, and a higher number of off-premise outlets within walking distance from home are associated with heavy alcohol consumption. The associations were determined between individuals using the whole sample of participants with two or more survey responses, and within individuals using data from participants whose distance to an outlet had changed and who had changed their drinking pattern between two surveys. The analysis within individuals means that we examined whether a *change* in distance to the nearest off-premise outlet is associated with a subsequent *change* in heavy alcohol consumption.

2. Methods

2.1. Study population

Data are from the Finnish Public Sector study cohort, an ongoing prospective study of employees working in 10 towns and 6 hospital districts (Kivimaki et al., 2010) that are located in the Southern and Western Finland (Supplementary Fig. 1[2]). The target organizations included all public sector workplaces, e.g., schools, day care centers, rest homes and health care centers, as well as 21 hospitals, and administration. The sex distribution of the present sample corresponds well with the Finnish public sector where most employees (teachers, nurses, etc.) are women. The eligible register cohort population included all employees who had been working for these organizations for a minimum of six months between 1991 and 2005, a total of 151,618 men and women. For 146,600 of them the geocoded latitude and longitude coordinates of their residential buildings in between January 1st, 2000 and December 31st, 2010 were obtained from the Population Register Center. They have reported that 90% of the residential building locations in whole Finland are correct with 20 m accuracy, and that in the city plan areas (where most participants resided) the coverage is the best (Väestörekisterikeskus [Population Register Centre], 2004).

Nested survey cohorts, based on current employees at the time of survey in the participating organizations (on average 75,000 eligible employees in each survey), have received questionnaires every four years between 2000 and 2008 (average response rate 69%). In 2005 and 2009, surveys were mailed also to those who completed questionnaires while employed, but had later left the organizations. The ethics committee of Hospital District of Helsinki and Uusimaa approved the study.

This study included all nested cohort members who were employed by the target organizations in 2000, 2004, and 2008 and responded to the surveys including questions on alcohol consumption in those years. These data were complemented with responses from the 2005 and 2009 surveys of the leavers. For 296 participants the residential coordinates were not available, and 1156 did not respond to questions related to alcohol use and they were excluded from the data. A total of 54,778 participants responded to at least two of these surveys and formed the analytic sample of this study. This sample is comparable to the eligible register cohort population in regard of sex distribution (81% in this sample, 78% in the eligible cohort), and age (44 years in this sample, 44 years in the eligible cohort).

2.2. Dependent variable: heavy alcohol consumption

The respondents reported their habitual frequency and amount of beer, wine, and spirits intake, which was transformed into grams of alcohol per week. The questions on alcohol consumption in this survey have also been used elsewhere (Kaprio et al., 1987; Poikolainen et al., 2005). One unit of pure alcohol (12 g) was equal to a 12 cl glass of wine, a 4 cl measure of spirits and a 33 cl bottle of beer. *Heavy alcohol use* was determined as 24 and 16 units (>288 g and >192 g) per week for men and women, respectively (Halonen et al., 2013). These limits correspond with the medium risk levels of daily consumption set by the World Health Organization (WHO, 2000).

2.3. Independent variables: proximity and number of off-premise alcohol outlets

The street addresses of all off-premise alcohol outlets (i.e., no consumption on the premises) in Finland with an active liquor license in 2004 or 2008 were derived from the Regional State Administrative Agency, the only licensing authority in Finland. First, most grocery and convenience stores as well as gas stations have a license to sell alcohol beverages with a maximum alcohol content of 4.7% alcohol by volume (e.g., beer). These outlets are referred to as "beer outlets." Second, liquor outlets operate under a state monopoly in Finland and are the only off-premise outlets where stronger alcohol beverages, including beer, wine, and spirits, can be purchased. These outlets are referred to as "liquor outlets." In total, street addresses (with street numbers) of 92% of the beer outlets ($n = 5319$), and 95% of the liquor outlets ($n = 313$) were successfully geocoded by a geocoding service and by manual search. These latitude and longitude coordinates were used for calculating the distances between participants' residences and the outlets, as well as the number of beer outlets within 1 km (0.6 miles) zone from home of the participant. Because license information for beer outlets was incomplete for year 2000, outlet locations in 2004 were used also for year 2000.

2.4. Covariates

Age, sex, and occupational status were obtained from employers' administrative registers. Occupational status was used as a proxy for individual socioeconomic status, SES, and as a possible confounder because the effects of alcohol use may differ between SES groups (Nielsen et al., 2004). Individuals were classified into three SES groups: high, intermediate, and low, based on Classification of Occupations by Statistics Finland (Statistics Finland, 1987), as in our earlier studies (Halonen et al., 2013; Kivimaki et al., 2007). Sub-optimal health (self-rated health of fairly poor or poor vs. other), and marital status (married or co-habiting vs. not) were also requested in the questionnaires.

Neighborhood socioeconomic characteristics have been associated with alcohol availability (Pollack et al., 2005). Measures of the possible confounding area characteristics in this study were calculated by Statistics Finland, and were based on the total population within each 250 m × 250 m map grid (Statistics Finland, 2007). An index of neighborhood socioeconomic disadvantage was calculated using the grid database information on median income, education attainment, and unemployment rate (Halonen et al., 2012a). Another area-level covariate was population density (residents per 1 km^2) that was used as a proxy for the degree of urbanization. These data were linked to the survey data using the GPS-coordinates of the participants' home addresses.

2.5. Statistical analyses

The median distance from home to the nearest beer outlet was 0.45 (range 0–38.5) km (0.58, 0–23.9 miles). Change in distance to the nearest beer outlet between two surveys was categorized as: (1) Remained long = distance remained ≥500 m (≥0.3 miles, reference), (2) Increased = distance increased from <500 m to ≥500 m, (3) Remained short = distance remained <500 m, and (4) Decreased = distance decreased from ≥500 m to <500 m. For distance to the nearest liquor outlet the categorization was similar, with a cut-point at 2 km (1.25 miles) because the median distance was 1.9 (range 0–131) km (1.2, 0–82 miles). Number of beer outlets within 1 km (0.6 miles) zone from home has been used as an exposure variable in prior cross-sectional studies (Connor et al., 2011; Kavanagh et al., 2011). In this study, the median number of beer outlets within 1 km from home was 3, thus, the number of beer outlets variable was categorized as: (1) Remained low = number remained ≤3 (reference), (2) Decreased = number decreased from >3 to ≤3, (3) Remained high = number remained >3, and (4) Increased = number increased from ≤3 to >3.

2.5.1. Between-individual analyses. To estimate the effects of distance to the nearest off-premise alcohol outlet and the number of off-premise beer outlets within 1 km zone on heavy alcohol use among all participants and at follow-up (i.e., those "incident users" who were not heavy users at baseline but were at the later survey), we used binomial logistic regression with the generalized estimating equations (GEE) method with neighborhood as the clustering variable (GENMOD procedure of SAS 9.2; SAS, 2001). This method includes all participants with two or more survey responses. To test whether availability affects alcohol consumption differently in men and in women, we included an interaction term to the regression models (heavy consumption ~ sex × distance to (or number of) outlet(s)). All models were then adjusted for age, (sex), marital status, sub-optimal health, neighborhood disadvantage, population density, and the number of beer outlets (distance variables in the density models). As sensitivity analyses we run the models adjusting for distance to an on-site outlet (Halonen et al., 2013) and used different cut-point distances for the exposures (25th percentiles: 250 m and 1 km, and means: 850 m and 3.3 km). The results for the categorical availability measures are provided as odds ratios (OR) with 95% confidence intervals (CI).

[2] Supplementary material can be found by accessing the online version of this paper. Please see Appendix A for more information.