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Is proximity to alcohol outlets associated with alcohol consumption and alcohol-related harm in Denmark?

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Abstract

Background: This study examined the associations between distance from residence to the nearest alcohol outlet with alcohol consumption as well as with alcohol-related harm. **Methods:** Data on alcohol consumption, alcohol-related harm and sociodemographics were obtained from the 2011 Danish Drug and Alcohol Survey ($n = 5133$) with respondents aged 15–79 years. The information on distances from residence to the nearest alcohol outlets was obtained from Statistics Denmark. Multiple logistic and linear regressions were used to examine the association between distances to outlets and alcohol consumption whereas alcohol-related harm was analysed using negative binomial regression. **Results:** Among women it was found that those living closer to alcohol outlets were more likely to report alcohol-related harm ($p < 0.05$). This was not true for men. No association was found between distances to outlets and alcohol consumption (volume of drinking and risky single occasion drinking). **Conclusions:** This study found some support for an association between closer distances between place of residence and alcohol outlets and alcohol-

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related harm for women. Future studies in the Nordic region should continue to examine the association between physical alcohol availability (nearest distance to an outlet and outlet densities) and alcohol consumption as well as alcohol-related problems using different outlet types.

Keywords
alcohol consumption, alcohol outlets, alcohol-related harm, alcohol-related problems, Denmark, distance, risky single occasion drinking

Over the past decade there has been considerable interest in examining the association of alcohol availability and alcohol consumption as well as alcohol-related harm. Availability of alcohol refers to its accessibility and the convenience thereof (Babor et al., 2010), which can be measured by outlet density or distance from residence to the nearest outlet (Halonen et al., 2013b). An outlet is a location in which alcohol may be sold legally for either on-premises (bars, pubs, restaurants) or off-premises (supermarkets, convenience stores, liquor stores) consumption. Outlet density refers to the number of physical locations in which alcohol is available for purchase either per area unit or per population (Campbell et al., 2009). In contrast, measures of outlet distance have employed travel distances along road networks or straight-line distances between locations; i.e., the closest distance from a respondent's home to an alcohol outlet (Grubesic, Wei, Murray, & Pridemore, 2016; Hay, Whigham, Kypri, & Langley, 2009).

Research has indicated that neighbourhoods with higher alcohol outlet density are positively associated with alcohol consumption (Schonlau et al., 2008), binge drinking (Connor, Kypri, Bell, & Cousins, 2011) and harmful alcohol consumption of residents (Pereira, Wood, Foster, & Haggar, 2013). In a systematic review, Popova, Giesbrecht, Bekmuradov, and Patra (2009) indicated that most of the reviewed studies found that greater alcohol outlet density had a positive impact on one or more of the studied alcohol outcome variables (overall alcohol consumption, drinking patterns, and damages). Despite the fact that a number of studies have found a significant association between outlet density and drinking, others found a small or no effect. In a recent Australian study, Lamb et al. (2017) found some evidence for the association between the number of alcohol outlets and harmful levels of drinking among women who lived in disadvantaged neighbourhoods in Victoria. However, the association was dependent on the distance threshold used. In another study, Pollack, Cubbin, Ahn, and Winkleby (2005), employing a multi-level analysis to examine the mediation effect of alcohol availability, measured by both density and distance, found that alcohol availability was not associated with heavy drinking among a sample of California residents. Overall, studies of the association between outlet density and alcohol consumption have produced mixed results (see Picone, MacDougald, Sloan, Platt, & Kertesz, 2010).

There are few studies which have examined the association of distance from home to the nearest outlet and alcohol consumption in the general adult population. Halonen et al. (2013a), using Finnish cross-sectional and longitudinal data, found that the closer one lived to a bar, the more likely one was to report risky alcohol behaviour. Similarly, in a cohort study, Halonen et al. (2013b) found that women who resided close to off-premises alcohol outlets were more likely to report heavy alcohol consumption. Using longitudinal data from four large US cities, Picone et al. (2010) found that numbers of bars within 0.5 km of a residence was associated with small increases in alcohol consumption.

With respect to alcohol-related harm, systematic literature reviews by Popova et al. (2009), Campbell et al. (2009), Kearns, Reidy, and Valle (2015) and Gmel, Holmes, and Studer (2016) have shown that greater alcohol availability was positively associated with alcohol-related harm. More specifically, research has shown a significant association between alcohol outlets and alcohol-related problems (Fone et al., 2016; Popova et al., 2009), assault rates (Livingston, 2008), rates of violent crime (Norstrom, 2000; Toomey et al., 2012), higher concentrations of robbery (Snowden & Freiburger, 2015), and mortality (Richardson, Hill, Mitchell, Pearce, & Shortt, 2015). It should be noted that most of the reviewed research has focused on examining second-hand alcohol effects; i.e., problems to those other than the drinker. A study by Connor et al. (2011) is a rare exception: it examined personal consequences of drinking and various types of alcohol outlets, and found that density of outlets was associated with an alcohol-related harm score.

In sum, most of the reviewed research shows that alcohol availability is associated with both alcohol consumption and alcohol-related problems. However, the results vary markedly by measures of alcohol consumption and alcohol-related harm, outlet type (Livingston, 2008) and distance thresholds. For instance, in their review study, Gmel et al. (2016) pointed out that when outlet types (i.e., on premises and off premises) are analysed separately, conclusions drawn from the reviewed studies are weaker due to methodological differences and inconsistent results. Similarly, Lamb et al. (2017) found that the association between outlet density and harmful levels of alcohol consumption was dependent on the distance threshold that the authors considered.

Research on alcohol outlets is relatively scarce in Europe as most of the studies have been carried out in North America and Australia (Holmes et al., 2014). Specifically, in Denmark, no study to date has investigated the association between alcohol outlets and drinking or alcohol outlets and alcohol-related harm. Furthermore, most of the published literature has investigated alcohol availability based on outlet density and has relied on highly aggregated outlet categories (Gmel et al., 2016). Thus, in an effort to further understand the influence of alcohol outlets on drinking and alcohol-related harm, this study aims to examine how exposure to different subcategories of alcohol outlets, measured by distance from place of residence to alcohol outlet, is associated with volume of drinking, risky single occasion drinking (RSOD) and alcohol-related harm in the Danish general population. We hypothesise that residing in areas close to outlets will be associated with a higher probability of self-reported alcohol consumption and one's own alcohol-related problems. We also expect that the relationship between distance to outlets and alcohol consumption as well as alcohol-related harm will differ by outlet type (Livingston, Chikritzhs, & Room, 2007). Furthermore, as men and women differ in regard to alcohol metabolism and social norms regarding alcohol use and alcohol expectations (Hensing & Spak, 2009), it is likely that our findings will differ by gender.

Data and methods

Sample

The data used in this article came from the 2011 national Danish alcohol and drug survey by the Centre for Alcohol and Drug Research and from the registries of Statistics Denmark. To collect the survey data, a representative random sample of 8000 persons between the ages of 15 and 79 years old was randomly drawn from the central person registration numbers (CPR). Potential respondents were invited by postal letter to complete an online questionnaire during September and October 2011. Telephone interviews were conducted with those individuals who had not responded after two reminders. The final sample consisted of 5133 respondents representing a response rate of 64%.

The survey contained all individual sociodemographic variables used in the analysis. Participants also were asked about alcohol consumption and alcohol-related harms. Registry data from Statistics Denmark provided additional information about the respondents' disposable income and distance to alcohol and tobacco outlets. We linked the most recent outlet distance data (2008) with the population registry data using residence location and municipality (*Kommune*) as merging variables. Next, we merged these data with the Alcohol and Drug survey using personal number as the merging variable. We were able to merge the data of 4511 respondents from the survey sample with these registry data. We were unable to merge 622 (12%) respondents due to missing data.

Alcohol consumption

We used two types of alcohol consumption indicators as outcome variables: mean volume of alcohol consumption per day in grams ethanol and frequency of RSOD. For mean volume of alcohol consumption, we summed four beverage-specific quantity/frequency questions to create an overall measure of mean total alcohol consumption in grams of pure alcohol per day. We defined RSOD as consuming five or more alcoholic drinks (a total of 60 and more grams of alcohol) on a single occasion. Prevalence of RSOD was derived from the survey question: "how often have you had five or more drinks in an occasion in the past 12 months?" Respondents could choose from various frequencies which we re-coded as one when respondents reported RSOD at least monthly in the last 12 months and zero otherwise (henceforth regular RSOD).

Alcohol-related personal consequences of drinking

Following Connor et al. (2011) a score of alcohol-related personal consequences of drinking was constructed based on the following questions: "During the last 12 months, has your drinking had a harmful effect: (1) on your work, studies, or employment, (2) on your housework or chores, (3) on your marriage/intimate relationship, (4) on your relationships with other family members, including your children, (5) on your friendships or social life, (6) on your physical life, or (7) on your finances?" The response categories to each sub-question were: no = 0; yes, once or twice = 1; yes, more than twice = 2. A harm score was calculated based on the sum of the above seven sub-questions which resulted in a range between 0 and 14 points.

Distance to alcohol outlets

Information on alcohol and tobacco outlets was obtained from Statistics Denmark. In this study, distance to outlets was defined as the shortest path in kilometres from a respondent's residence to the nearest outlet, which was calculated using a straight-line measure. As alcohol outlets, we included pubs, kiosks (corner convenience stores) and supermarkets. Tobacco shops were also included as they are likely to sell alcohol as well. The list of outlets is not exhaustive and we have analysed only outlets for which we have enough information in the data set. There have been few specialised alcohol stores in Denmark and the data set from Statistics Denmark did not include them. Furthermore, the category of bars included neither restaurants nor nightclubs. The outlets are categorised as: (1) on-premises outlets: pubs (including bars) and (2) off-premises outlets: kiosks, tobacco shops and supermarkets.

Other covariates

The sociodemographic variables used in the analyses include age, income, education, employment status, civil status, living with children, and residence areas. Age was categorised into four groups: 15–24 years, 25–39 years, 40–64 years, and 65 years and older. Education was categorised into three groups: completion of up to 10 years of schooling (low);

upper secondary and vocational, i.e., up to 12 years of schooling (middle); college or university, i.e., up to 20 years of schooling (high). We also included annual personal disposable income, and to reduce skewness, natural logarithmic transformation was used. Employment status consisted of five groups: employed and self-employed; student; pensioner; unemployed; and other including home maker. Civil status comprised three categories: living in a relationship; not in a relationship; and single. We also included a binary indicator of whether or not a respondent was living with children younger than 18 years. A binary indicator of religiosity (i.e., attending worship and religious ceremonies more than four times in the last 12 months) and a binary indicator of whether or not the respondent lived in urban areas (cities) were also included in the analyses.

Statistical analyses

We tested for gender differences in the mean of the study variables by using an independent sample *t*-test. As there were significant gender differences, all analyses were stratified by gender. We examined the association between the outcome variables and each independent variable, including the outlets, by using Spearman's correlation rank test. Multiple logistic regression was conducted to determine whether distance to outlets was associated with regular RSOD. The Hosmer–Lemeshow test (Lemeshow & Hosmer, 1982) was used to assess the fit of the model. The relationship between distance from residence to the nearest alcohol outlets and volume of alcohol consumption was assessed using multiple linear regression. Furthermore, we examined the association between distance to outlets and alcohol-related consequences (harm score) using a negative binomial regression model, which is often used for over-dispersed count outcomes (more variation) (Cameron & Trivedi, 2009). Furthermore, as sensitivity analyses, we repeated the negative binomial analyses by restricting the data to a higher frequency of regular RSOD and volume of drinking. That is, we included respondents who reported RSOD at least weekly in one specification, and respondents who reported drinking above the average volume of alcohol in another specification. This helped us to conduct our analyses using multiple consumption dimensions, which has rarely been a focus of previous studies (Holmes et al., 2014) and to feel more confident that our results were statistically robust.

In all analyses, a separate estimation was made for each outlet variable. Sociodemographic variables, defined above, were controlled for in all estimations since these variables were found to be significantly associated with both drinking and alcohol-related harm in previous studies conducted in Denmark (Seid, Hesse, & Bloomfield, 2016) and elsewhere (Connor et al., 2011; Helasoja et al., 2007). *P*-values are for two-tailed tests and we used an alpha level of 0.05 as the cut-off for level of significance. All analyses were performed using STATA version 14.0 software (Stata Corporation, College Station, TX).

Results

Table 1 displays descriptive statistics of the study variables. About one-third of respondents reported engaging in regular RSOD at least once a month. In all of the three outcome variables (average volume of alcohol, regular RSOD, and harm scores), men had significantly higher values than women. The majority of respondents reported being in the middle age group, being in the middle educational group, being employed, being in a relationship, and living in cities. In regard to outlet distances, tobacco shops were the farthest from and kiosks were the nearest to respondents' residences and on average men were more likely to live at greater distances than women to all types of outlets.

Table 2 summarises the results of the gender-stratified multiple logistic regressions with frequency of regular RSOD as the

Table 1. Study sample characteristics by gender.

Variables	Per cent or mean (*SD*)			
	Total ($n = 5131$)	Women ($n = 2709$)	Men ($n = 2421$)	*P*-values[2]
RSOD[1]	31.0%	22.3%	40.8%	< 0.001
Volume of drinking (grams ethanol per day)	12.8 (21.1)	8.5 (14.4)	17.6 (25.8)	< 0.001
Harm score [range 0–14]*	0.44 (1.36)	0.35 (1.16)	0.56 (1.56)	0.014
Age (in years)				0.541
15–24	16.5%	15.4%	17.8%	
25–39	20.1%	20.3%	19.8%	
40–64	46.6%	48.3%	44.8%	
65+	16.8%	16.0%	17.7%	
Disposable income [in 1000 DKK]	206.0 (207.0)	189.9 (112.5)	225.8 (275.4)	0.113
Education				< 0.001
Low	22.5%	21.8%	23.3%	
Middle	45.9%	42.5%	49.7%	
High	31.6%	35.7%	27.0%	
Employment status				< 0.001
Employed	53.5%	50.7%	56.6%	
Student/Apprentice	13.3%	13.8%	12.7%	
Pensioner	22.7%	23.9%	21.4%	
Unemployed	2.9%	3.2%	2.5%	
Other	7.7%	8.4%	6.8%	
Civil status				0.764
In a relationship	71.4%	70.6%	72.3%	
Not in a relationship	9.7%	12.0%	7.1%	
Single	18.9%	17.4%	20.6%	
Living with children under the age of 18	31.3%	32.5%	29.9%	0.047
Religiosity[3]	17.8%	19.7%	15.8%	< 0.001
Living in an urban area	61.9%	63.0%	60.6%	0.080
Distance of outlets (in kilometres)				
Pubs	2.37 (2.74)	2.21 (2.64)	2.55 (2.86)	< 0.001
Kiosks	1.52 (1.66)	1.46 (1.62)	1.58 (1.70)	0.011
Tobacco shops	8.61 (8.10)	8.40 (8.29)	8.84 (7.89)	0.070
Supermarkets	1.99 (2.48)	1.89 (2.40)	2.10 (2.55)	0.003

[1]Risky single occasion drinking was defined as drinking 5+ standard units at least once a month.
[2]Results of proportion of equality chi-square test between men and women.
[3]Attended worship and religious ceremonies more than four times in the last 12 months.
* Harm score was based on the following questions: "During the last 12 months, has your drinking had a harmful effect: (1) on your work, studies, or employment, (2) on your housework or chores, (3) on your marriage/intimate relationship, (4) on your relationships with other family members, including your children, (5) on your friendships or social life, (6) on your physical life, or (7) on your finances?"

outcome variable. A separate logistic regression was estimated for each type of alcohol outlet, controlling for all covariates. We found no significant associations between the distance to each type of outlet and regular RSOD, although all estimated odds ratios were either at or under 1, indicating the tendency for either a null or an inverse relationship between distance and frequency of regular RSOD.

The results of linear regression models using log volume of drinking as the outcome variable are displayed in Table 3. For both men and

Table 2. Gender-stratified multiple logistic regression models of the effect of distance to outlets on risky single occasion drinking (odds ratios; 95% confidence intervals).

	Men			Women		
	n	*OR* (95% CI)	R^{2a}	*n*	*OR* (95% CI)	R^{2a}
On-premises outlets						
Pub	2036	0.98 (0.94–1.03)	0.07	2288	0.98 (0.93–1.04)	0.18
Off-premises outlets						
Kiosks	2036	0.96 (0.91–1.03)	0.07	2288	0.96 (0.89–1.04)	0.18
Tobacco shops	2036	1.00 (0.98–1.01)	0.07	2288	1.00 (0.99–1.01)	0.18
Supermarkets	2036	0.98 (0.94–1.03)	0.08	2288	0.99 (0.94–1.05)	0.18

Note. Risky single occasion drinking (RSOD) was defined as drinking 5+ standard units at least once a month. Separate regression was estimated for each outlet variable controlling for age, income, education, employment status, civil status, living with children aged under 18, religiosity and urbanisation (living in cities).
[a]Pseudo R^2.

Table 3. Gender-stratified linear regression models of the effect of distance to outlets on mean alcohol consumption (logged) (beta coefficients, standard error).

	Men			Women		
	n	β (*SE*)	R^2	*n*	β (*SE*)	R^2
On-premises outlets						
Pub	2036	–0.01 (0.01)	0.05	2288	–0.00 (0.01)	0.10
Off-premises outlets						
Kiosks	2036	0.00 (0.01)	0.05	2288	0.00 (0.01)	0.10
Tobacco shops	2036	–0.00 (0.00)	0.05	2288	–0.00 (0.00)	0.10
Supermarkets	2036	–0.00 (0.01)	0.05	2288	–0.00 (0.00)	0.10

Note. Risky single occasion drinking (RSOD) was defined as drinking 5+ standard units at least once a month. Separate regression was estimated for each outlet variable controlling for age, income, education, employment status, civil status, living with children aged under 18, religiosity and urbanisation (living in cities).

women, and after controlling sociodemographic correlates, again, no statistically significant association was observed between the distance to outlets and log volume. All of the estimated coefficients were either zero or negative.

Finally, the results of negative binomial regressions using our constructed harm score as an outcome variable are reported in Table 4. Similar to our previous multiple logistic and linear regression models, a separate estimation was conducted for the distance to each outlet type adjusting for sociodemographic variables. The results indicated that women who resided closer to pubs, tobacco shops and supermarkets were significantly more likely to report harm than women residing farther from such outlets. None of the regressions was statistically significant for men.

In order to have more confidence in our results for women, we conducted sensitivity analyses in which we used more extreme cut-off points for alcohol consumption (drinking above mean volume of drinking and reporting RSOD at least once in a week) to see whether the results remained statistically significant. The association between the harm score and pubs as well as supermarkets was robust to

Table 4. Gender-stratified negative binomial regression models of the effect of distance to outlets on alcohol harm score.[†]

	Men			Women		
	n	β (*SE*)	R^{2a}	*n*	β (*SE*)	R^{2a}
On-premises outlets						
Pub	954	0.08 (0.06)	0.04	1031	–0.15 (0.06)**	0.10
Off-premises outlets						
Kiosks	954	0.01 (0.06)	0.05	1031	–0.05 (0.08)	0.08
Tobacco shops	954	0.01 (0.02)	0.05	1031	–0.04 (0.02)*	0.09
Supermarkets	954	0.01 (0.05)	0.05	1031	–0.18 (0.06)**	0.09

Note. Control variables included age, income, education, employment status, civil status, living with children, religiosity, and urbanisation (living in a city).

[†]Harm score was based on following question: "During the last 12 months, has your drinking had a harmful effect: (1) on your work, studies, or employment, (2) on your housework or chores, (3) on your marriage/intimate relationship, (4) on your relationships with other family members, including your children, (5) on your friendships or social life, (6) on your physical life, or (7) on your finances?"

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

[a]Pseudo R^2.

changes in specification for women (data not shown). We also confirmed that our main results for men on the association between distance to outlets and harm were not sensitive to the use of extreme cut-off points of alcohol consumption. Furthermore, we have included an interaction term of urbanity with all distance variables to examine whether our results differed between urban and rural areas. However, all the interaction terms were found to be insignificant, indicating that the results do not differ between rural and urban areas.

Discussion

This study set out to examine the relationship between distance from residence to the nearest alcohol outlet and alcohol consumption (measured as volume of drinking and risky single occasion dinking) as well as alcohol-related harm among a representative sample of the Danish adult general population. In particular, we hypothesised that closer proximity to an alcohol outlet would be associated with a greater likelihood of consuming more alcohol, of engaging in more frequent risky single occasion drinking and of reporting more alcohol-related harm. One of these hypotheses was borne out for women with respect to alcohol-related harm: those who lived closer to pubs, tobacco shops and supermarkets were more likely to report harm, even after accounting for individual covariates. However, similar results were not found for men nor for other alcohol indicators for either sex.

The fact that we found a lack of association between the nearest outlet and alcohol consumption corresponds to previous findings by Kavanagh et al. (2011) who found similar results for proximity of alcohol outlets and harmful alcohol consumption in Melbourne, Australia. Also, in a US study, Pollack et al. (2005) reported no association between alcohol outlets and greater alcohol consumption among California residents. However, based on both cross-sectional and longitudinal data, Halonen et al. (2013b) found that distance to off-premises alcohol outlets in Finland was associated with heavy alcohol consumption in women, but not in men. Furthermore, the same authors found that proximity to a bar increased the odds of risky drinking among both men and women. The relative lack of an association between distance to nearest outlets and alcohol consumption in our study might be explained by a Danish-specific preference for particular

drinking sites. Research has indicated that Danes prefer to drink at home and in comparison to other Scandinavian countries, and that they appear to drink less often at a restaurant or bar (Grønkjær, Vinther-Larsen, Curtis, Grønbæk, & Nørgaard, 2010). At least for on-premises outlets, this could partly explain the lack of an association for consumption.

Our results on the association between distance to outlets and alcohol-related harm may indicate gender differences in consumption and the experience of harm as indicated in another study (Halonen et al., 2013b). As Karriker-Jaffe and Greenfield (2014) have pointed out, the risk of experiencing alcohol-related harm is higher among men as they may prefer to congregate more often with heavy drinkers than do women. Furthermore, women are more likely to report more alcohol-related violence at home whereas men were more likely to report violence in the street and at bars (Fillmore, 1985).

Our findings are consistent with a study by Connor et al. (2011) of the New Zealand general population who found that density of off-premises outlets was not associated with any form of alcohol consumption, but that there was an association with density of off-premises outlets and an increased harm score. However, the study conducted no gender-stratified analyses to reveal any potential gender differences. Our findings are also consistent with a study among US American college students that found that outlet density was associated with more alcohol-related harm among female students, but not among males (Weitzman et al., 2003).

It is difficult to hypothesise why we find significant results only for women with regard to proximity and alcohol-related harm. Although women reported a lower mean number of harms than did men, the nature of the harms could still be seen to apply more to women than men. That is, our list of harms is more relationally oriented (e.g., harm to marriage, family life, children, friendships and social life) rather than consisting of externally directed harm (e.g., reporting fights, accidents, etc.). Furthermore, a question could be raised that our survey might lack the same representation of men in urban areas as in rural ones, which could lead to this association. Place of residence, however, has been one of the variables included in our survey weights, thus making such a possibility less likely. However, this issue might be more related to a discrepancy in preferences for living locations between men and women. Perhaps some women may prefer living in suburbs and more rural areas than do men, leading to a "gendered" distribution of residence. Unfortunately, we know of no studies that have specifically investigated such a possibility.

Despite these speculations our results of the association between alcohol outlet distance and alcohol-related harm among women appear to be reliable, even though the harm score is less pronounced in women (mean score = 0.35) than in men (mean score = 0.56). Regarding the corresponding beta coefficients, the negative association between outlet distance and harm score was relatively substantial (β = –0.18 and 0.15) for supermarkets and pubs respectively compared to other results in our study (β = –0.01 to 0.08). Moreover, we observed three out of four possible associations among women to be negative and significant: those between pubs, tobacco shops, and supermarkets and harm. Finally, the associations for supermarkets and pubs also appeared significant in the sensitivity analyses where we restricted analyses to persons with high consumption.

Some of the cited studies have indeed shown that alcohol availability is associated with alcohol consumption and alcohol-related harm with stronger evidence being provided by studies which used natural experiments. Such research includes a study of sudden change in outlet density (see Gmel et al., 2016 for review). For instance, Stockwell et al. (2009, 2011) examined the impact of a dramatic increase in the density of private liquor stores in British Columbia, Canada. Their results demonstrated that private liquor stores were found to be significantly associated with alcohol sales and

alcohol-related mortality. The discrepancy between our results and the few others that have examined alcohol outlets might be explained partly by variations in sample, outcome measures, and types of outlets. In most of the previous studies alcohol availability has been measured by outlet density; furthermore only one study by Connor et al. (2011) examined the association between density of outlets and individual alcohol-related harm. As Halonen et al. (2013a) have pointed out, outlet density measures are limited as they may not describe as effectively the exposure of residents living in the centre of an area as compared to those at the periphery. Because of this, density measures may not fully capture the association between outlets and consumption as well as alcohol-related harm. We also acknowledge that as most people's daily routines take them into different areas for work, recreation, shopping, et cetera, simple adjacency to one's home may not be a very sensitive measure, and therefore the possibility that proximity of alcohol to one's residence may not always be such a strong determining factor of alcohol consumption and harm.

The main strengths of our study include the use of distance to outlets to measure alcohol availability, the fairly large sample size that includes individual-level survey data, and the use of standardised measurement of variables. However, we acknowledge a number of limitations in our study. Firstly, the study was based in part on cross-sectional survey data and thus we cannot establish causality between distances from residence to the nearest outlets and the outcome variables. Secondly, distance to alcohol outlets was measured before the survey data were collected. Thus, due to the possibility of closures and new openings of outlets, the number of alcohol outlets (to measure distance from home to an outlet) used in our analyses may differ from the outlets operating at the time of the survey. This suggests that caution is needed when interpreting our results. However, the set of data from Statistics Denmark that we chose was the most recently collected before our survey data collection. Thirdly, we employed distance to outlets as our availability measure as we do not have information on density of outlets nor gravity measures. In this regard, Grubesic et al. (2016) reviewed different outlet measures and concluded that standard measures of outlet density can lead to biased estimates of physical availability that over-emphasise the influence of the control variables, whereas gravity measures provide a more balanced, geographically sensitive measure of access to alcohol outlets. Fourthly, although self-reported alcohol consumption is standard practice in alcohol survey research we cannot rule out the risk of recall bias. Nonetheless, recall bias in alcohol surveys usually produces non-differential misclassification which can lead to underestimation of associations and therefore conservative estimates (Meiklejohn, Connor, & Kypri, 2012). Fifthly, although the response rate (64%) for our survey is relatively higher than in other recently conducted general population alcohol surveys, we cannot rule out non-response bias. However, this bias might not be of major concern as the mean alcohol consumption in our study is comparable to official estimates of the national per capita alcohol consumption. Furthermore, although studies have shown that alcohol outlet density is positively associated with neighbourhood deprivation, we were unable to control for neighbourhood characteristics (Fone et al., 2016; Ngui, Apparicio, Philibert, & Fleury, 2015). In future research, measures of neighbourhood deprivation could be derived from population registry data.

In summary, this is the first Danish national study investigating distance from home to outlets in relation to drinking and alcohol-related harm. Although we did not find an association between distance from home to the nearest outlets with regard to alcohol consumption (risky single occasion drinking and volume drinking), we did find a significant relationship between distance to alcohol outlets and alcohol-related harm among women. Thus, our findings for alcohol-related problems suggest that women's

experience of such harms might not only be influenced by individual factors, but also by environmental factors such as proximity of alcohol outlets.

From a public health policy perspective, regulating alcohol outlets through zoning and licensing has been shown to reduce excessive alcohol consumption and related harm (Kearns et al., 2015). However, given that our limited results are the only findings so far on the subject in Denmark; further study is required to determine whether regulating alcohol outlets reduces alcohol consumption and related harm in this country. Additionally, since our results indicate strong associations between distance to outlets and alcohol-related harm only in women, further research is needed to tease out gender differences. Furthermore, future Danish research could focus on examining the association between alcohol availability (both distance to the nearest outlet and outlet density) and alcohol consumption as well as alcohol-related problems by disaggregating alcohol outlets by license types. It is also worth exploring whether the association is influenced by other factors such as price (Hobday et al., 2017) and neighbourhood characteristics.

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