Does Neighborhood Alcohol Availability Moderate the Impact of Familial Liability and Marital Status on Risk for Alcohol Use Disorders? A Swedish National Study

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ABSTRACT. Objective: The purpose of this study was to determine whether ease of access to alcohol at the neighborhood level moderates the impact of familial liability and marital status on risk for alcohol use disorder (AUD). **Method:** Individuals in Sweden were divided into those residing in a neighborhood with ($n = 14.1\%$) versus without ($n = 85.9\%$) an alcohol outlet (bars/nightclubs or government stores). AUD was detected through national medical, legal, and pharmacy registries. Using an additive model predicting AUD registration over 5 years in 1,624,814 individuals, we tested for interactions between the presence of outlets in the individuals' neighborhoods and familial risk for externalizing syndromes and marital status. **Results:** In both males and females, we found positive and significant interactions in the prediction of AUD

between the presence versus absence of a nearby alcohol outlet with (a) familial risk and (b) single and divorced versus married status. Similar but nonsignificant interactions were seen between nearby outlets and widowed versus married status. These results changed little when all cases with prior AUD were removed from the sample. For males, most of the interaction arose from the proximity of bars/nightclubs, whereas for females the results varied across different kinds of outlets. **Conclusions:** Environments that provide easy access to alcohol augment the impact of a range of risk factors for AUD, especially familial vulnerability and the reduced social constraints associated with single, divorced, and widowed marital status. (*J. Stud. Alcohol Drugs*, 81, 816–823, 2020)

ENVIRONMENTS THAT ENFORCE normative social behavior, including stable neighborhoods and marriage, reduce risk for alcohol use disorder (AUD) and buffer against the impact of genetic influences (Dick & Kendler, 2012). By contrast, environments with low social control—such as the state of divorce (Kendler et al., 2017) and/or neighborhoods with high alcohol availability—can increase AUD risk (Wagenaar et al., 2009; Weitzman et al., 2003) and augment the impact of genetic factors (Dick & Kendler, 2012; Kendler et al., 2011; Slutske et al., 2019). The question of the association between alcohol availability and AUD

is an old one. In his “History of Alcoholism,” Sournia (Sournia & Porter, 1990) comments on the historical debate over whether Henry III’s 1587 edict to expand access to alcohol in local cabarets in France was the cause of the subsequent rise of alcoholism in his country. He writes: “The relation between alcoholism and access to alcohol . . . remains a vexed question today” (Sournia & Porter, 1990, pp. 18–19).

In prior studies on AUD conducted in the Swedish population, we have shown in both adoption studies (Kendler et al., 2015) and twin and sibling studies (Kendler et al., 2016c) that AUD runs strongly in families as a result of both genetic and familial environmental factors. Compared with being single, marriage conveys a substantially reduced risk for AUD (Kendler et al., 2016b), whereas compared with being married, being divorced or widowed is associated with a large increase in risk for AUD (Kendler et al., 2017). Last, consistent with prior evidence (Popova et al., 2009), individuals residing in neighborhoods in Sweden with alcohol outlets have an elevated risk for AUD (Karriker-Jaffe et al., 2018). In this and prior work, we defined outlets as on-premise bars/nightclubs with liquor licenses and off-premise government-

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run stores, which are the only place in Sweden where wine, strong beer, and distilled spirits can be purchased for home consumption.

Following up on these prior inquiries, this article examined whether alcohol availability in Sweden, indexed by neighborhood alcohol outlets, moderates the impact of familial liability and marital status on AUD risk. We hypothesized that high familial risk and the states of being single, divorced, or widowed versus being married would each produce larger increases in cases of AUD in areas of high versus low alcohol availability. Because of potential differences in drinking patterns at home versus in public (Mustonen & Sund, 2002), we then explored whether any interactions between familial risk, marital status, and alcohol availability differed for on- versus off-premise alcohol outlets.

Method

We linked nationwide Swedish registers via the unique 10-digit identification number assigned at birth or immigration to all Swedish residents. The identification number was replaced by a serial number to ensure anonymity. The following sources were used to create our data set: the Total Population Register, containing information about year of birth, sex, family, and marital status; the Multi-Generation Register, linking individuals born after 1932 to their parents; the Hospital Discharge Register, containing hospitalizations for Swedish inhabitants from 1964 to 2015; the Prescribed Drug Register, containing all prescriptions in Sweden picked up by patients from 2005 to 2015; the Outpatient Care Register, containing information from all outpatient clinics from 2001 to 2015; the Crime Register, comprising national complete data on all convictions in the lower court from 1973 to 2015; and the Swedish Suspicion Register, comprising national data on individuals strongly suspected of crimes from 1998 to 2015. For this study, we included men and women born in Sweden between 1960 and 1990 and registered in Sweden in 2005.

Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. We secured ethical approval for this study from the Regional Ethical Review Board of Lund University (No. 2008/409).

Measures

Individual AUD status was identified from Swedish medical registries by the following ICD codes: ICD-8: 571.0, 291,

303, 980; ICD-9: V79B, 305A, 357F, 571A, 571B, 571C, 571D, 425F, 535D, 291, 303, 980; ICD-10: E244, G312, G621, G721, I426, K292, K700, K701, K702, K703, K704, K709, K852, K860, O354, T510, T511, T512, T513, T518, T519, F101, F102, F103, F104, F105, F106, F107, F108, F109; and from the Prescribed Drug Register if prescribed disulfiram (Anatomical Therapeutic Chemical [ATC] Classification System N07BB01), acamprosate (N07BB03), or naltrexone (N07BB04). In addition, we identified AUD as convicted for or suspected of at least two alcohol-related crimes according to law 1951:649, paragraph 4 and 4A; law 1994:1009, Chapter 20, paragraph 4 and 5 from the Swedish Crime Register; and code 3005 and 3201 in the Suspicion register.

To assess familial liability, we created a familial risk score (FRS) for externalizing behavior (EB) as a function of registrations of EB in these family members: biological parents, monozygotic twins, full siblings, half-siblings, and cousins. To account for the age-dependence EB risk, each relative's risk was weighted by their age at the end of follow-up using the following weighting system: lowest age quartile and no registration of EB got a weight of 0; the two middle age quartiles and no registration of EB got a weight of 0.5; and highest age quartile or any registration of EB got a weight of 1. To account for multiple siblings and cousins, we created a measure that represents the respective proportion of full siblings, half-siblings, and cousins who were registered for EB. The familial risk was assessed by logistic regression where the morbid risk measures for each relative type were included as covariates. Our FRS corresponds to the predicted probabilities, based on the estimated parameters from this model.

Because the distribution of genetic risk scores was skewed, we included the logarithms of the predicted probabilities in the statistical model. EB was defined as any registration of AUD, criminal behavior, or drug use disorder. Criminal behavior was identified by registration for either violent crime, property crime, or white-collar crime in the Swedish Crime register. Prior analyses in Sweden showed a high level of sharing of familial risk factors for AUD, drug use disorder, and criminal behavior (Kendler et al., 2016a). For the definition of *drug use disorder*, see the Appendix. (A supplemental appendix appears as an online-only addendum to this article on the journal's website.)

Marital status was assessed at baseline and obtained from the Total population register. Neighborhoods were defined using Small Areas for Market Statistics (SAMS) obtained from Statistics Sweden, the Swedish government-owned statistics bureau. There are approximately 9,400 SAMS throughout Sweden, with an average population of about 1,000 inhabitants. The SAMS boundaries are drawn to include similar types of housing construction. In qualitative studies, SAMS units have been shown to be consistent with how residents define their neighborhoods. Neighborhoods

TABLE 1. Descriptive statistics of the samples examined

Sex	Risk	Variable	No outlets in SAMS		≥1 outlet in SAMS		Difference in risk [95% CI]
			Total	AUD in 5 years	Total	AUD in 5 years	
Male	Low	No FH for EB	388,980	9,227 (2.4%)	61,453	1,879 (3.1%)	0.7% [0.5, 0.8]
	High	FH for EB	325,045	16,452 (5.1%)	53,748	3,455 (6.4%)	1.4% [1.2, 1.6]
	Low	Married	364,069	6,273 (1.7%)	49,401	1,037 (2.1%)	0.4% [0.2, 0.5]
	High	Unmarried	245,416	12,314 (5.0%)	46,634	2,772 (5.9%)	0.9% [0.7, 1.2]
	High	Divorced	97,587	6,828 (7.0%)	17,952	1,474 (8.2%)	1.2% [0.8, 1.7]
	High	Widowed	3,127	163 (5.2%)	522	39 (7.5%)	2.3% [-0.1, 4.6]
Female	Low	No FH for EB	369,610	3,638 (1.0%)	60,298	806 (1.3%)	0.4% [0.3, 0.5]
	High	FH for EB	312,442	7,047 (2.3%)	53,238	1,586 (3.0%)	0.7% [0.6, 0.9]
	Low	Married	378,301	3,139 (0.8%)	52,320	532 (1.0%)	0.2% [0.1, 0.3]
	High	Unmarried	178,889	3,568 (2.0%)	35,706	905 (2.5%)	0.5% [0.4, 0.7]
	High	Divorced	113,475	3,707 (3.3%)	23,379	906 (3.9%)	0.6% [0.3, 0.9]
	High	Widowed	8,301	242 (2.9%)	1,536	48 (3.1%)	0.2% [-0.7, 1.2]

Notes: SAMS = Small Areas for Market Statistics; AUD = alcohol use disorder; CI = confidence interval; FH = family history—that is, the presence of one or more affected relatives; EB = externalizing behavior.

with alcohol outlets were defined as SAMS with at least one bar, nightclub, or government store in 2005. Included in our definition of government store are local agents where individuals can pre-order alcoholic beverages that are then delivered for pick-up.

Statistical methods

To estimate the influence of alcohol outlets on future AUD we used additive hazard models. An advantage of these models is the use of an additive scale where the parameter estimates represent additional number of new cases with AUD per person year. As a consequence, interactions are on an additive scale, which facilitates the prediction of the additional number of cases per person years when additional risk factors are present. Although there is a debate about whether interactions should be assessed on additive versus multiplicative scales, we have argued for the public health perspective, which wants to know the number of new cases arising from interacting causes and hence adopt the additive model (Kendler & Gardner, 2010).

We performed univariable analysis and estimated the association between AUD within 5 years after 2005 and for each single covariate (Model 1) and created a multivariable model including the main effects of all covariates (Model 2). To further explore how living in a neighborhood with an alcohol outlet might moderate the risk of developing AUD depending on familial liability or marital status, we included the interactions between neighborhood outlet status (e.g., presence/absence of an outlet) and the logarithm of familial risk and marital status, respectively. In Model 3, we included the interaction between outlet status and the logarithm of genetic risk in addition to all other covariates. In Model 4, we instead included the interaction between outlet status and marital status. Model 5 contained both interactions. In addition, as a sensitivity check, we re-ran all analyses for men and women without a history of AUD. Last, we ran Model

5, first to examine outlets with bars/nightclubs, excluding all SAMS with only government outlets, and second, to analyze SAMS with government outlets, excluding SAMS with only bars/nightclubs. Analyses were done in SAS Version 9.4 (SAS Institute Inc., Cary, NC), Rstudio Version 1.1.456 (RStudio, 2018), and the *timereg* package in R (Martinussen & Scheike, 2006).

Results

Findings in entire sample

We summarized key descriptive features of our samples in Table 1. Our total sample consisted of 1,624,814 individuals (51% male), of whom 14.1% resided in a neighborhood with one or more alcohol outlets. Within our 5-year target period, 3.7% of males and 1.6% of females had an AUD registration. A total of 3.5% of men and 1.8% of women in our cohort had a prior AUD registration. Of the 9,403 neighborhoods in our analyses, 91.7% had no alcohol outlet, 4.1% had only a bar or nightclub, 2.6% had only a government-run store, and 1.7% had both.

Several trends were evident in the raw numbers in Table 1. First, having a positive family history for EB and being single, divorced, or widowed were associated with higher rates of AUD registration in both males and females. Second, across all subgroups divided by family history and marital status, the risk for AUD was higher for those residing in a neighborhood with versus without an alcohol outlet. Third, the difference in risk between those living in a neighborhood with versus without an alcohol outlet was higher in those at high risk (positive family history or single, divorced, or widowed) than those at low risk (negative family history or married).

We then examined the impact of our key risk factors on risk for AUD in men and women (Appendix Table 1). Given that significant differences were seen in nearly all analyses,

TABLE 2. Parameter estimates for prediction model of risk for alcohol use disorder (AUD) registration in males as a function of familial risk and marital status and their interaction with the presence of a nearby alcohol outlet

Variable	Increased risk per 10,000 person-years [95% CI]				
	Uni-variable model	Multi-variables models			
	Model 1	Model 2	Model 3	Model 4	Model 5
Main effects					
SAMS with outlet	9.3 [7.8, 10.7]	5.4 [4.0, 6.9]	16.0 [6.2, 26.0]	2.6 [1.0, 4.2]	12.4 [2.7, 22.2]
Log EB FRS	46.9 [45.3, 48.5]	25.8 [24.2, 27.3]	25.0 [23.3, 26.7]	25.8 [24.2, 27.4]	25.1 [23.4, 26.7]
Unmarried vs. married	28.2 [27.3, 29.2]	15.6 [14.7, 16.5]	15.6 [14.7, 16.5]	15.1 [14.1, 16.1]	15.1 [14.2, 16.1]
Divorced vs. married	49.8 [47.9, 51.8]	32.3 [30.4, 34.3]	32.3 [30.4, 34.3]	31.3 [29.3, 33.4]	31.4 [29.3, 33.4]
Widowed vs. married	35.2 [23.8, 46.5]	25.4 [14.0, 36.7]	25.4 [14.0, 36.8]	20.8 [9.1, 32.4]	20.8 [9.1, 32.4]
Low vs. high education	35.0 [33.4, 36.5]	12.9 [11.4, 14.4]	12.9 [11.4, 14.4]	12.9 [11.4, 14.5]	12.9 [11.4, 14.5]
Mid vs. high education	20.7 [19.8, 21.5]	8.4 [7.6, 9.2]	8.4 [7.6, 9.2]	8.4 [7.6, 9.3]	8.4 [7.6, 9.3]
Previous AUD	407.2 [397.2, 417.2]	392.8 [382.9, 402.7]	392.8 [382.9, 402.7]	392.7 [382.8, 402.7]	392.7 [382.8, 402.7]
Interactions					
Outlet $\times$ log EB FRS			5.5 [0.7, 10.3]		5.0 [0.2, 9.8]
Outlet $\times$ Unmarried				4.0 [1.2, 6.8]	3.7 [0.9, 6.5]
Outlet $\times$ Divorced				7.2 [1.4, 13.1]	6.9 [1.0, 12.7]
Outlet $\times$ Widowed				33.4 [-6.7, 73.6]	33.5 [-6.7, 73.6]

Notes: CI = confidence interval; SAMS = Small Areas for Market Statistics; EB = externalizing behavior; FRS = familial risk score.

we conducted our main effect and interaction analyses separately in the two sexes.

Our five models for men predicting changes in risk for AUD registration per 10,000 person-years are seen in Table 2. Model 1 presents univariable findings of our key main effects and covariates. A prior AUD registration was far and away the strongest predictor of future registrations, followed by divorce and increased familial risk for EBs. Residing in a neighborhood with an alcohol outlet produced a moderate increased risk for AUD. Model 2 presents these same variables but now in a multivariable model with the expected decrease in effect size for several parameters. Model 3 demonstrates a significant interaction between outlet status and familial risk for EBs in the prediction of AUD. Controlling for other variables in the model, for each additional unit increase of the log of the FRS for EBs, living in a neighborhood with versus without an alcohol outlet was associated with an increase of 5.5 cases of AUD per 10,000 person-years.

Model 4 examines the interactions between the presence of alcohol outlets and marital status. Being single versus married and divorced versus married were both associated with a significantly increased risk for AUD registration when living in a neighborhood with versus without an alcohol outlet. However, the interaction was more than twice as large for divorced versus married as it was for single versus married status. Being widowed versus married was also associated with a higher AUD risk for people in an outlet-containing neighborhood, but given the wide CIs because of the rarity of widowhood in our data, these results were far from significant. Last, Model 5 examined our four possible interactions together in a single model. We again see significant positive interactions between outlet status and FRS, being single versus married, and being divorced versus married.

Table 3 depicts results of our five models predicting risk for AUD registration in women. The results were very simi-

lar to those seen in men. We found significant interactions between neighborhood alcohol outlet status and familial risk for EBs, married versus single status, and married versus divorced status in the prediction of AUD risk. As with men, the interaction with widowhood showed a similar trend but is nonsignificant.

Findings excluding cases with prior alcohol use disorder registration

The effect size of a prior AUD registration dwarfed that of all other variables in the model. To assess the stability of our results, we therefore examined only onsets of AUD by removing individuals from our sample with the highest risk for AUD. We repeated our analyses in both men and women, excluding all cases of prior AUD registration (Appendix Tables 2 and 3). In males, of the four interactions we examined, the interaction between outlet status and FRS for EBs declined moderately and was no longer statistically significant; the interaction with single versus married did not change, between divorced versus married increased somewhat, and between widowed and married increased more than sixfold, although it remained nonsignificant. In females, the three interactions seen in the entire sample all remained significant when those with prior AUD were excluded. The effect size of the interactions both with FRS for EBs and for divorced versus married both declined moderately.

Bars/nightclubs versus government outlet stores

We then examined the impact on risk on AUD for residing in a neighborhood with on- versus off-premise alcohol outlets, that is separating bars/nightclubs from government stores (Table 4). Examining the full multivariable model only (equivalent to Model 5 in Tables 2 and 3), for men, sig-

TABLE 3. Parameter estimates for prediction model of risk for alcohol use disorder (AUD) registration in females as a function of familial risk and marital status and their interaction with the presence of a near-by alcohol outlet

Variable	Increased risk per 10,000 person-years [95% CI]				
	Uni-variable model	Multi-variables models			
	Model 1	Model 2	Model 3	Model 4	Model 5
Main effects					
SAMS with outlet	5.0 [4.0, 6.0]	3.3 [2.3, 4.3]	13.9 [6.7, 21.1]	1.3 [0.2, 2.4]	11.3 [4.2, 18.4]
Log EB FRS	24.2 [23.0, 25.3]	14.4 [13.3, 15.5]	13.6 [12.4, 14.8]	14.4 [13.3, 15.5]	13.7 [12.5, 14.8]
Unmarried vs. married	10.7 [10.0, 11.4]	6.2 [5.5, 6.8]	6.2 [5.5, 6.8]	5.9 [5.2, 6.6]	5.9 [5.2, 6.6]
Divorced vs. married	23.7 [22.5, 24.9]	15.4 [14.2, 16.5]	15.4 [14.2, 16.5]	14.5 [13.2, 15.7]	14.5 [13.3, 15.8]
Widowed vs. married	21.2 [16.3, 26.1]	15.2 [10.3, 20.1]	15.2 [10.3, 20.1]	14.4 [9.2, 19.6]	14.4 [9.2, 19.6]
Low vs. high education	21.5 [20.0, 23.0]	9.3 [7.8, 10.8]	9.3 [7.8, 10.8]	9.3 [7.8, 10.8]	9.3 [7.8, 10.8]
Mid vs. high education	7.3 [6.7, 7.9]	2.8 [2.2, 3.4]	2.8 [2.2, 3.4]	2.8 [2.2, 3.4]	2.8 [2.2, 3.4]
Previous AUD	327.2 [314.5, 340.0]	318.5 [305.8, 331.2]	318.5 [305.8, 331.2]	318.5 [305.8, 331.2]	318.5 [305.8, 331.2]
Interactions					
Outlet × log FRS			5.6 [2.0, 9.1]		5.1 [1.6, 8.7]
Outlet × Unmarried				2.4 [0.4, 4.4]	2.1 [0.1, 4.1]
Outlet × Divorced				6.0 [2.5, 9.5]	5.6 [2.1, 9.1]
Outlet × Widowed				5.8 [-9.1, 20.7]	5.7 [-9.2, 20.6]

Notes: CI = confidence interval; SAMS = Small Areas for Market Statistics; EB = externalizing behavior; FRS = familial risk score.

nificant interactions were seen in the prediction of AUD risk for FRS, single versus married, and divorced versus married with access to bars or nightclubs but not with the neighborhood presence of government outlet stores. In women, the results were more complex. As in men, a significant interaction with familial risk was seen only for bars/nightclubs and not for government stores. However, the reverse pattern was seen for single versus married, with interactions only seen for access to government stores and not bars/nightclubs. For divorced versus married, the interactions were nearly identical and significant for both bars/nightclubs and government stores.

Discussion

This report sought to determine whether, using large epidemiological samples and objectively assessed measures, we could demonstrate an interaction between alcohol availability and two key AUD risk factors: (a) familial liability to externalizing disorders and (b) marital status in which we examined three high-risk states (being single, divorced, or widowed) in comparison with the low-risk state of being married. We examined men and women separately.

Results confirmed our expectations. In every analysis in both sexes, interactions were positive. The risk for AUD was greater in each high-risk group when they did versus did not reside near alcohol outlets. These results were statistically significant in both sexes for familial liability and for both single and divorced versus married status. In both men and women, the effects were large but not significant for the status of being widowed versus married.

To assess the validity of these findings, we repeated the analyses, pulling out all cases of prior AUD from our sample so that we were examining only AUD onset. In these analyses, results were similar to those of the full sample,

with the sole difference being that the interaction between familial liability and alcohol availability in males fell short of statistical significance. The similarity of these findings suggests that the augmentation of key risk factors for AUD by environments that provide easy access to alcohol is likely to be qualitatively similar in first-onset and recurrent cases.

These results are consistent with prior literature on the role of social constraints more broadly and alcohol availability more specifically in moderating the effects of familial risk on alcohol consumption and/or problems. Two prior studies are of relevance. First, in an examination of 1,796 adult male twins using a life history calendar of key environmental exposures and alcohol consumption in adolescence (Kendler et al., 2011), familial effects on alcohol use in adolescence were considerably more pronounced when the twins reported high versus low alcohol availability. Second, in a study of 2,434 18- to 26-year-old twin, full-, and half-sibling pairs from Wave III of the National Longitudinal Study of Adolescent to Adult Health, the heritability of alcohol use increased as a function of the number of alcohol outlets in the neighborhood (Slutske et al., 2019). Our study goes beyond these to examine AUD in a population of adults, finding similar moderating effects.

A range of individual-level environmental exposures in addition to alcohol availability, including low parental monitoring and regular contact with substance-using friends, augment the effects of familial influences on substance use (Dick & Kendler, 2012). Neighborhood-level influences with a similar moderating effect included communities with greater in- and out-migration (with this residential instability suggesting reduced social bonds between residents, and thereby weaker social controls) and with high percentages of older adolescents/young adults (suggesting greater social modeling of substance use behaviors). These observations fitted within a broad theoretical position that the effect of

TABLE 4. Parameter estimates for full prediction model of risk for alcohol use disorder (AUD) registration in males and females as a function of exposure to bars/nightclubs versus government stores

Variable	Increased risk per 10,000 person-years [95% CI]			
	Full model			
	Male		Female	
	Bars/nightclubs	Government stores	Bars/nightclubs	Government stores
Main effects				
SAMS with outlet	19.2 [7.6, 30.8]	11.5 [-0.8, 23.8]	14.1 [5.5, 22.7]	6.5 [-2.3, 15.4]
Log EB FRS	25.0 [23.3, 26.7]	25.0 [23.4, 26.7]	13.7 [12.5, 14.8]	13.6 [12.5, 14.8]
Unmarried vs. married	15.1 [14.1, 16.0]	15.1 [14.1, 16.0]	5.9 [5.2, 6.6]	5.9 [5.2, 6.6]
Divorced vs. married	31.4 [29.3, 33.4]	31.5 [29.4, 33.5]	14.6 [13.3, 15.8]	14.6 [13.3, 15.8]
Widowed vs. married	20.8 [9.2, 32.5]	20.9 [9.3, 32.6]	14.4 [9.2, 19.6]	14.5 [9.3, 19.7]
Low vs. high education	13.0 [11.5, 14.6]	12.8 [11.2, 14.3]	9.5 [8.0, 11.0]	9.5 [8.0, 11.0]
Mid vs. high education	8.4 [7.6, 9.3]	8.5 [7.6, 9.3]	2.9 [2.3, 3.4]	2.8 [2.2, 3.4]
Previous AUD	393.2 [383.0, 403.5]	392.0 [381.7, 402.2]	316.7 [303.7, 329.8]	316.9 [303.8, 330.0]
Interactions				
Outlet $\times$ Log FRS	8.3 [2.5, 14.0]	4.7 [-1.4, 10.7]	6.3 [2.0, 10.5]	3.2 [-1.2, 7.6]
Outlet $\times$ Unmarried	5.0 [1.7, 8.3]	2.5 [-1.0, 6.0]	1.3 [-1.1, 3.6]	3.5 [1.0, 6.0]
Outlet $\times$ Divorced	7.2 [0.3, 14.1]	4.3 [-3.0, 11.6]	5.5 [1.5, 9.6]	5.6 [1.2, 9.9]
Outlet $\times$ Widowed	45.5 [-4.7, 95.7]	11.4 [-32.7, 55.6]	9.6 [-8.9, 28.1]	2.5 [-15.2, 20.2]

Notes: CI = confidence interval; SAMS = Small Areas for Market Statistics; EB = externalizing behavior; FRS = familial risk score.

liability to alcohol use and misuse, as well as with related EB, is sensitive to both factors reflecting social control and opportunity to use alcohol, which have an impact on differential expression of individual predispositions (Shanahan & Hofer, 2005).

Our finding that alcohol availability interacts with marital status adds nuance to the considerable epidemiological evidence that being single, divorced, or widowed is associated with increased risk of AUD compared with being married (Grant et al., 2015; Staff et al., 2010). We and others have previously shown that the transition to marriage has a causal, protective effect against AUD risk (Horn et al., 2013; Kendler et al., 2016b), whereas the loss of marriage through divorce or widowhood is likely to have a causal, pathogenic effect on AUD risk (Kendler et al., 2017). Such findings are consistent with theoretical frameworks suggesting that people are motivated to behave in ways that are consistent with their social roles (Yamaguchi & Kandel, 1985), that spouses are likely to monitor one another's health behaviors (Umberson, 1992), and that some divorced and widowed individuals might drink to cope with their loss and/or the resultant loneliness.

The present study goes beyond these earlier effects to demonstrate that the lack of a protective marriage is particularly pronounced in environments where alcohol is readily available. To our knowledge, this is the first study that demonstrates how a proximal social role (marital status) interacts with the broader environmental context (i.e., alcohol availability) to affect AUD risk, and suggests that constraints, or lack thereof, at multiple levels have conjoint effects (Windle, 2010).

Our final analyses examined interactions with the two available types of alcohol outlets: (a) bars/nightclubs in which alcohol would have to be purchased and consumed

on-site and (b) government stores in which various forms of alcoholic beverages would be purchased for consumption off-site. For males, significant interactions with familial risk and marital status were only seen for access to bars/nightclubs, whereas for women the results were more mixed with, for example, interactions between single versus married status only being seen for access to government stores. Although we cannot claim to fully understand the origins of these differences, it is noteworthy that with the liberalization of access to alcohol in Finland in the 1960s, both women and men increased their drinking occasions at home, with only men increasing the frequency of alcohol consumption in public places, such as bars (Mustonen & Sund, 2002).

Perhaps women in Sweden are, especially with the lack of a marital partner, more prone to drink excessively in private, whereas men in the same situation prefer drinking heavily in the company of their friends in bars/nightclubs. Data from the United States suggest a dominant subgroup of heavy drinking women who do not drink much in public venues while drinking mostly at home, and a dominant subgroup of heavy drinking men who drink in many different types of venues including at home and in bars (Nyaronga et al., 2009). Future research in Sweden is needed to confirm these findings.

One obvious methodological concern regarding these analyses is our assumption that the direction of effect goes from alcohol outlets to AUD risk. It is plausible that those at high risk for AUD would seek out environments with high alcohol availability. However, we examined this question in our prior analysis of alcohol outlets using a co-sibling design (Karriker-Jaffe et al., 2018). The overall association between residence in a neighborhood containing at least one alcohol outlet and risk for AUD in our analyses of more than 2.5 million individuals in our fully adjusted model was equal to

a hazard ratio of 1.16 (95% CI [1.13, 1.19]). In our analysis of siblings discordant for alcohol outlets within their neighborhoods, the risk for AUD was 1.19 (95% CI [1.15, 1.24]). Given the strength with which AUD aggregates in families, these findings suggest that little of our observed association in the Swedish population is the result of active selection of at-risk individuals into neighborhoods with high alcohol availability.

Limitations

This report should be interpreted in the context of five potential methodological limitations. Most importantly, our measures of AUD were based entirely on public registries. This method has important advantages because it does not require subject cooperation or accurate recall of events often happening years before. But this method is not equivalent to large-scale personal interview studies, and, against that standard registry, studies are likely to produce both false-negative (individuals with AUD who never had medical or legal attention) diagnoses and false-positive (individuals arrested or treated for alcohol-related problems without truly having an AUD) diagnoses. We cannot precisely estimate these biases. First, given that the population prevalence of AUD in our samples is lower than estimates from most epidemiological surveys, including one from nearby Norway (Kessler et al., 1994; Kringlen et al., 2001), false-negative diagnoses are much more likely than false-positive diagnoses. The validity of our definition of AUDs, however, is further supported by the high rates of concordance for registration across our different ascertainment methods (Kendler et al., 2015).

Second, given the government restrictions on alcohol sales in Sweden, there are relatively few alcohol outlets in the country, which limits the variety of alcohol availability measures that can be measured in a national study. Nonetheless, these measures do provide objective assessments of the geographical proximity of different types of alcohol outlets at a national level.

Third, AUD registrations are not likely a precise index of the onset or recurrence of AUD. In an informative study of the age at which 21 alcohol-related symptoms occurred in a large cohort of male alcohol-dependent patients (Schuckit et al., 1993), those symptoms that would likely lead to detection in Sweden through the medical or criminal registries began, on average, 3–5 years after the first meaningful clinical symptoms of occupational difficulties and the substantial drinking binges.

Fourth, perhaps alcohol outlets do not have a causal effect on risk for AUD but instead are just indices of levels of urbanization or neighborhood deprivation. We addressed this question in our previous article on outlets in which we showed that alcohol outlets predicted risk for AUD in SAMS from rural and urban settings and neighborhoods with low and high levels of deprivation (Karriker-Jaffe et al., 2018).

Last, Sweden is a high-income socialist democracy with high levels of social services. Although our expectation is that the general trends uncovered in these analyses—that easier alcohol access augments the impact of a number of key risk factors for AUD—are broadly applicable across diverse cultural settings, this needs to be empirically demonstrated.

Conclusions

Using large-scale nationwide data, we produced evidence—consistent across both sexes and including versus excluding individuals with prior AUD registrations—that higher alcohol availability, measured by residence in a community with alcohol-serving bars/nightclubs and government-run stores, interacted with familial liability as well as with single or divorced marital status to increase the risk for AUD registration. Consistent with prior empirical and theoretical work, ease of access to alcoholic beverages increased the adverse effect of other key risk factors on AUD. We found sex differences in the prediction of AUD from the interaction between access to on- versus off-premise alcohol with familial risk and marital status. In aggregate, these results provide both useful theoretical support for models of AUD etiology and possible actionable points for prevention methods to reduce the burden of alcohol problems.

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