Abstract

While neighborhood conditions have been linked to alcohol misuse, less is known about the long-term consequences of exposure to adverse neighborhood conditions early in the life course for alcohol misuse. Using data from the National Longitudinal Survey of Adolescent to Adult Health, we examined how trajectories of alcohol behaviors from ages 12 to 32 varied according to neighborhood disorder, disadvantage, and advantage. Early exposure to adverse neighborhood conditions placed individuals at greater risk of being a current drinker and alcohol misuse, though these individuals never reached the same levels as those in more stable, advantaged neighborhoods. Early exposure appears to place individuals at risk for alcohol misuse across the early life course.

Keywords: neighborhoods; alcohol misuse; life course; social disorganization

Alcohol use and the problems that arise from it remain a serious threat to public health (World Health Organization, 2014). The factors that contribute to the varying stages and severity alcohol use (e.g. initiation of use, regular consumption, heavy use, and alcohol-related problems) stem from multiple levels including social structural, interpersonal, and genetic influences. Research on the relationship between neighborhood context and alcohol-related behaviors has helped improve our understanding of how neighborhood conditions, including economic, social, and physical conditions, can alter an individual's ability to lead a healthy life, especially in regards to alcohol misuse. In the current analyses, we determine whether early life neighborhood conditions have implications for trajectories of alcohol misuse across adolescence and into early adulthood.

Broader social and economic forces pattern the social conditions within neighborhoods. Economic disadvantage at a neighborhood level (often assessed using census based socioeconomic indicators) is associated with greater levels of neighborhood disorder and crime (Sampson et al., 1997). Neighborhood disorder is characterized by the presence of both physical disorder (e.g. litter, graffiti, dilapidated buildings) and social disorder (e.g. open drug use or sales, teenage peer groups loitering). This increase in disorder occurs primarily through weakened local institutions like the family and schools (Wilson, 2012). For example, adolescents in these neighborhoods are at heightened risk of dropping out of school (Harding, 2003) or coming from single-parent families (South and Crowder, 1999), increasing the likelihood they spend large portions of time unsupervised. Additionally, as fear and mistrust of neighbors spreads, adults may become less willing to intervene when they witness young people acting out in public spaces (Sampson et al., 1997), resulting in the breakdown of a neighborhood's ability to maintain informal social control (or collective efficacy). The greater levels of disorder in these

disadvantaged neighborhoods also leads to greater ambient hazards like fear of victimization (Aneshensel and Sucoff, 1996), and exposure to violence (Turner et al., 2013).

Both the breakdown in social control and increase in exposure to psychosocial stressors are thought to be primary mechanisms by which neighborhood disadvantage influences the alcohol use of residents, as neighborhood disadvantage is associated with increases in consumption frequency, heavy/binge drinking, alcohol problems, and negative consequences from drinking, even after accounting for a variety of individual-level covariates related to both alcohol use and neighborhood composition (Cerdá et al., 2010, Karriker-Jaffe et al., 2012, Mulia and Karriker-Jaffe, 2012, Jones-Webb and Karriker-Jaffe, 2013). These effects may vary across individual characteristics like race and gender, with neighborhood disadvantage being related to increased alcohol misuse among Black men and White women, but reduced misuse among White men (Karriker-Jaffe et al., 2012). Additionally, both concurrent neighborhood disadvantage as well as cumulative exposure over time have profound effects on frequency of consumption and binge drinking (Cerdá et al., 2010), suggesting that the longer individuals are exposed to disadvantaged environments, the stronger the influence of that exposure.

Beyond neighborhood socioeconomic conditions specifically, many of the characteristics related to disadvantage are also associated with alcohol misuse. Neighborhood disorder is independently associated with heavy/hazardous drinking (Hill and Angel, 2005, Kuipers et al., 2012). Alcohol outlet density, which is related to a broad range of alcohol related behaviors (Ahern et al., 2013, Livingston, 2011), is much greater in impoverished areas (Romley et al., 2007), making access to alcohol in disadvantaged contexts much easier. Alongside easier access, part of the relationship between neighborhood disadvantage and adolescent alcohol use is explained by greater exposure to substance using peers (Ying-Chih et al., 2005), a consistent risk

factor for adolescent alcohol misuse (Brechwald and Prinstein, 2011). Therefore, disadvantaged neighborhoods tend to provide a context with increased opportunity for risky behaviors, through easier access to alcohol and exposure to peer substance use.

Relatively little work has examined early exposure to adverse neighborhood conditions or the influence these exposures may have on long-term patterns of alcohol behaviors. Early exposure to neighborhood disadvantage has long-term influences on violent behavior (Karriker-Jaffe et al., 2011), aggression (Karriker-Jaffe et al., 2013), and broader externalizing problems (Wheaton and Clarke, 2003), which are correlated with alcohol use disorders later in life (Kendler et al., 2003). Early life exposure to neighborhood disadvantage is also related to alcohol problems in young adulthood, through the impact that neighborhood disadvantage has on educational attainment and young adult social functioning (Karriker-Jaffe et al., 2018). Given this previous research, we would expect early exposure to neighborhood disorder and/or neighborhood disadvantage should place individuals at greater risk of alcohol use and misuse across the early life course.

It is important to note that while there is evidence of the relationship between neighborhood characteristics (including both disadvantage and disorder) and alcohol misuse, recent systematic reviews of adolescent (Jackson et al., 2014) and adult (Algren et al., 2015) samples suggest that the direction and strength of this relationship is still ambiguous. This ambiguity could be due to a number of factors. First, these reviews combine the results of different levels in severity of alcohol misuse. Additionally, certain aspects of neighborhoods may be more relevant during different periods of the life course. Understanding whether certain neighborhood characteristics have specific influences on different levels in severity of alcohol

use and whether this varies as a function of stage in the life course is an important step in understanding this relationship.

In the current analysis, we explore the following research questions using a nationally representative sample of adolescents followed through young adulthood: 1) to what extent do neighborhood conditions, including neighborhood advantage, neighborhood disadvantage, and neighborhood disorder influence trajectories of three alcohol-related behaviors of increasing severity (current drinking status, overall monthly consumption, and heavy consumption); and 2) do these relationships remain after accounting for important risk factors at the individual level? Examining these different outcomes across the early life course allows us to establish what influences aspects of neighborhoods are important for varying stages of alcohol use above and beyond proximal risk factors.

Methods

The data for this analysis come from the National Longitudinal Study of Adolescent to Adult Health (Add Health). Add Health participants were selected from a stratified sample of 132 schools resulting in an initial, nationally representative sample of 90,118 students in grades 7-12. Of the original sample, 20,745 were selected for additional in-home interviews. Of those who completed the first in home interview in 1994-1995, 14,738 (71%) completed the second interview in 1996, 15,197 (73%) completed the third interview in 2001-2002, and 15,701 (75%) completed the fourth interview in 2007-2008 (Harris, 2009). The study period covered roughly 14 years between Waves I and IV, providing data ranging from adolescence (11-18 years old) into young adulthood (24-34 years old). Because the analyses are structured on age rather than the wave of data collection, the analyses cover a twenty-year period of the early life course.

Respondents were connected to neighborhood level data drawn from the U.S. Census. We limited analyses to individuals with appropriate survey weights and a valid neighborhood grouping indicator. The final sample included 18,740 individuals spread across 2,344 neighborhoods (Mean observation per neighborhood = 7.99, SD = 20.20, Range = 1 – 275). Results from analyses were robust to inclusion of neighborhoods with extremely large or small numbers of respondents (available on request). Of those included in the current analysis, individuals averaged approximately 3.2 observations of a possible 4 across each alcohol behavior.

Neighborhood Measures

Neighborhood Disadvantage/Advantage scales were constructed using items from 1990 census data linked to respondents' homes at Wave I, used previously in research with Add Health data (Harding, 2009). Exploratory factor analysis revealed two distinct factors. All items for neighborhood disadvantage (percent in poverty, percent female headed households, percent Black, and percent male unemployment) loaded heavily on a single factor while the remaining measures of neighborhood advantage (percent aged 25 and older with a college degree, percent managerial/professional occupations, percent households earning $75k or more a year) loaded on another. The scale for both disadvantage (a = .88) and advantage (a = .93) demonstrated high reliability. Neighborhood disadvantage and advantage were standardized and coded so that so that greater values reflected greater levels of each.

Neighborhood Disorder consisted of items measured at Wave I aggregated to the neighborhood level using the ecometrics approach (Mujahid et al., 2007, Raudenbush and Sampson, 1999). Items included ratings from the child, parents, and field interviewer and were

made up of perceptions of neighborhood safety, problems, and physical neglect, all of which are related to neighborhood disorder (Sampson et al., 1997). In order to create the scale, we fit a three-level logistic regression with items nested within individuals who were nested within neighborhoods, allowing respondents to contribute observations regardless of whether they had complete responses. Items demonstrated moderate clustering at the neighborhood level (intraclass correlation = .22). Neighborhood disorder scores are calculated from the standardized estimates of posterior means at the neighborhood level. Greater values indicated greater levels of disorder. The scale demonstrated relatively high reliability (mean = .67, SD = .22) based on a weighted comparison of between neighborhoods to within neighborhood variation (Raudenbush and Sampson, 1999). Neighborhood disorder was moderately correlated with both neighborhood disadvantage (r = .66) and neighborhood advantage (r = -.56) in expected directions, adding to the validity of the measure. A full description of the items and scale creation can be found in supplementary materials.

Individual Measures

Family Socioeconomic Status was measured using the scale developed specifically for the Add Health data (Bearman and Moody, 2004), combining mother or father's education and occupational category, yielding a score for each parent from 1 to 10. The final score was determined by whose score (of the mother and father in the case of both parents being present) was higher. *Race-ethnicity* was composed of five categories, of various racial-ethnic groups. Categories were coded so that African-Americans, Asian/Pacific Islanders, Hispanics, and those who identified as “other” were compared to non-Hispanic whites. Those who identified as being multi-racial were categorized under the racial-ethnic identity with which they most strongly identified. *Sex* was included as a binary variable. *Self-esteem* was included to account in part, for

important psychosocial resources related to mental health using a short-item version of the Rosenberg Self-Esteem scale (Rosenberg, 1965), that demonstrated relatively high reliability (a =.84). *Family composition* was a categorical variable those who lived with both parents to those who live with one or neither biological parents.

Additional Covariates

We included additional covariates in order to account for possible confounding. At the neighborhood level, we included a measure of social cohesion and stability consisting of both census data (proportion of homeowners and the proportion of occupied housing units moved into 1985-1990) and the ecometrics approach (Wave I In-home survey that asked the child how well they know the people in their neighborhood, how often they stop and talk to people on the street, and whether people in the neighborhood look out for one another). Measures of stability and social cohesion were standardized and combined into a single scale (a =.66) to improve reliability (full description available upon request). At the individual level, we included other measures related to either future alcohol use or comorbid behaviors, including self-rated health (Kerr et al., 2016), foreign-born status (Gfroerer and Tan, 2003), parental alcohol misuse (Verhulst et al., 2015), and low birth-weight, or < 5.5lbs (Aarnoudse-Moens et al., 2009). Finally, we included measures of urbanicity and the number of years the respondent had lived at their current address. All items were measured at Wave I.

Alcohol-Related Behaviors

Current drinking status was measured at each wave, asking respondents "Have you had a drink of beer, wine, or liquor—not just a sip or a taste of someone else's drink—more than 2 or 3 times in your life?" Those who answered yes were coded as 1. We refer to this as current

drinking status rather than initiation because the questions do not reflect the exact age at which an individual first initiated alcohol use. *Monthly consumption* represented the average number of drinks respondents had per month. This measure was created by combining two items asking how many days respondents had drank in the past 12 months (Never; 1 or 2 days in past 12 months; Once a month or less; 2 or 3 days/month; 1 or 2 days/week; 3-5 days/week; Every day/almost every day) and the number of drinks each time. We first converted days drinking into a pseudo monthly (30 day) metric, as others using ordinal measures of alcohol use/misuse have done in previous research (Dick et al., 2001, Barr et al., 2016). We then multiplied by the number of typical drinks to estimate total drinks per month. We set the max values of number of typical drinks at 10 to limit the influence of extreme outliers. *Heavy drinking* was the average of two items asking respondents in the past year how often they drank five or more drinks in a row and became drunk from alcohol, developed previously in research using Add Health (Chen and Jacobson, 2012). Items were converted to a pseudo monthly so that heavy drinking represented the number of heavy drinking days per month. Consumption and heavy drinking were log-transformed to adjust for heavy skew.

Analytic Strategy

We fit a series of linear (for monthly consumption and heavy drinking) and generalized linear (for current drinking status) mixed-effects models, which are well suited to handle longitudinal data that is unbalanced and/or has unique response schedule (Fitzmaurice et al., 2012, Singer and Willett, 2003). For the current analysis, we fit two-level models with observations nested within individuals over time using the *mixed* command combined with the *cluster* option in Stata 14. This allowed us to in order to incorporate the sampling weights for the Add Health Data and account for any clustering at the neighborhood level.

The model fitting process went as follows: 1) determine the functional form that each alcohol behavior followed over the course of time, through both visual inspection of the data and fitting linear and higher order polynomial models to compare fit statistics, 2) determine the appropriate structure of the random effects components of the model using nested models, and 3) examine whether neighborhood conditions altered trajectories of these alcohol behaviors. To assess whether neighborhood characteristics significantly contributed to either initial status or change over time, we examined both individual estimates and improvements in overall model fit. We determined improvement in model fit using Akaike's Information Criteria (Akaike, 1974), as the traditional likelihood ratio tests are not feasible when using sample weighted data. We included Add Health longitudinal survey weights to account for sample attrition and used multiple imputation (MI) to account for item non-response using the *ice* package. We followed the guidelines of missing imputation, then deletion (MID) in which all variables from the analysis, including the outcomes, are used in the imputation models and previously missing cases on the outcome variables were reset to missing before analysis (von Hippel, 2007). In the final models evaluating our primary research questions, we included the effects of neighborhood characteristics and sex on both initial status and change over time because prior evidence in Add of differences in trajectories across sex in the Add Health data (Chen and Jacobson, 2012). We examined the possibility of sex differences in the effect of neighborhood conditions by fitting sex-stratified models. We present only the combined models in this report, as the results were identical to the sex-stratified models. All other covariates were included for their effect on initial status only; in order to limit the number of estimated parameters. The age categories at the ends of the age spectrum were collapsed due to small cell sizes. For the analysis, the age ranges from 12 and below, to 32 and above.

Table 1: Sample-Weighted Descriptive Statistics for Add Health

	Females: N/Mean	%/SE	Males: N/Mean	%/SE	Range	
W1: Current drinker	5,283	55.18 %	5,239	56.29 %	-	
W2: Current drinker	3,282	49.27 %	3,097	47.94 %	-	
W3: Current drinker	5,603	76.06 %	5,211	78.70 %	-	
W4: Current drinker	5,958	78.46 %	5,653	83.89 %	-	*
W1: Alcoholic drinks consumed per month	4.64	0.30	9.19	0.61	0 – 300	*
W2: Alcoholic drinks consumed per month	5.49	0.39	9.73	0.76	0 – 300	*
W3: Alcoholic drinks consumed per month	11.16	0.57	26.88	1.16	0 – 300	*
W4: Alcoholic drinks consumed per month	9.43	0.41	24.81	0.91	0 – 300	*
W1: Days of heavy drinking per month	0.63	0.04	1.17	0.07	0 – 30	*
W2: Days of heavy drinking per month	0.77	0.06	1.40	0.10	0 – 30	*
W3: Days of heavy drinking per month	0.92	0.06	2.17	0.10	0 – 30	*
W4: Days of heavy drinking per month	0.83	0.05	1.93	0.08	0 – 30	*
W1: Age	15.3	0.11	15.42	0.12	11 – 21	
W2: Age	16.42	0.11	16.54	0.11	13 – 22	
W3: Age	21.58	0.12	21.73	0.12	17 – 28	
W4: Age	28.11	0.11	28.26	0.12	24 – 34	
Neighborhood disadvantage	-0.02	0.06	-0.03	0.06	-1.12 – 6.76	
Neighborhood advantage	-0.02	0.08	-0.02	0.08	-1.61 – 5.17	
Neighborhood disorder	-0.02	0.06	0.01	0.06	-2.87 – 3.66	
Neighborhood social cohesion	0.03	0.05	0.03	0.05	-2.86 – 1.64	
Family SES	5.80	0.11	5.86	0.11	1 – 10	
Self-esteem	4.02	0.01	4.20	0.01	1 – 5	*
Self-rated health	3.8	0.02	3.95	0.02	1 – 5	*
Years at current residence	6.95	0.14	6.96	0.15	0 – 21	

White	5,014	65.83 %	4,834	65.07 %	-
Black	2,113	16.53 %	1,871	16.45 %	-
Hispanic	1,615	12.67 %	1,598	12.72 %	-
Asian	619	3.47%	700	3.80%	-
Other	169	1.51%	171	1.95%	-
Lives w/ both biological parents	4,185	54.66 %	4,166	55.08 %	-
Lives w/ one biological parent	3,332	40.77 %	3,100	40.30 %	-
Lives w/ neither biological parents	525	4.57%	520	4.62%	-
Parental alcohol misuse	1,265	18.18 %	1,132	17.07 %	-
Born in US	8,678	93.50 %	8,325	94.15 %	-
Immigrated younger than 5	300	2.46%	302	2.10%	-
Immigrated from 5 to 12 years old	318	2.62%	326	2.51%	-
Immigrated age 12 and older	218	1.41%	201	1.24%	-
Low birth weight	816	8.57%	672	7.27%	-
Lives in urban area	5,415	53.10 %	5,190	53.86 %	-
N	9550		9190		

All measures other than age, and alcohol behaviors come from the Wave I data (1994-1995)
W1 = Wave I; W2 = Wave II; W3 = Wave III; W4 = Wave IV
* Difference in mean/proportion across sex is significant $p < .05$ based on T-test/Chi-square test.

Results

Table 1 includes the sample-weighted descriptive statistics broken down by sex. Males exhibited significantly greater levels of monthly consumption and heavy drinking across all four waves of data, and were significantly more likely to be a current drinker during Wave IV. Males also had significantly greater self-reported health and self-esteem. These significant differences

across alcohol behaviors throughout the life course reiterate the importance of including sex differences in both overall levels as well as in change over time.

Figure 1 presents the mean/proportions for each alcohol-related behavior across the full age range in Add Health by sex. A quadratic function for change over time best represented the change of each of these behaviors over time. Results from model fitting confirmed the observations from visual inspection, with the inclusion of linear and quadratic terms each adding significantly to overall model fit, respectively. A more detailed description of the model fitting and results are available upon request. In terms of the random effects structure, we fit each model with random effects for initial status, the linear slope of age, and the covariance between the two.

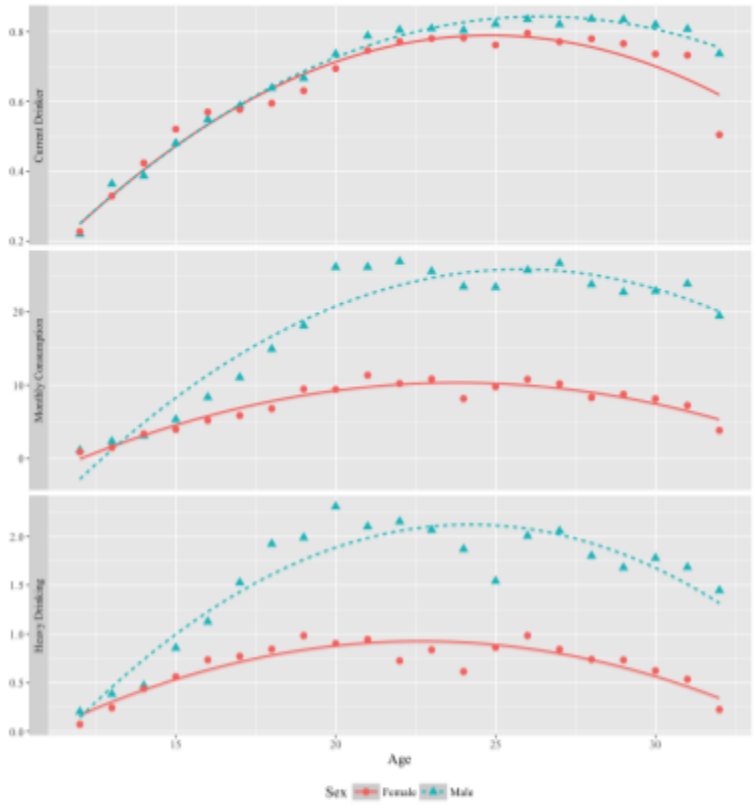


Figure SEQ Figure * ARABIC 1: Mean Levels of Current Drinking Status, Monthly Consumption, and Heavy Drinking across Time in Add Health

Proportion of those initiated, mean levels of consumption, and mean levels of heavy drinking across ages 12 to 32 by sex in the Add Health sample. Lines show the best fitting quadratic line to the data.

Table 2 presents the results for neighborhood characteristics from the mixed-models for each level alcohol use. Beginning with the unadjusted models for current drinking status, we see that neither neighborhood advantage nor disadvantage was associated with initial drinking status, though increases in neighborhood disadvantage slightly reduced the odds of being a current drinker over time (OR=0.930). However, neighborhood disorder was positively associated with increased risk of being a current drinker at baseline (OR=1.426), slower growth in odds of being a current drinker over time (OR=0.908), and a slightly slower decline in the odds of being a current drinker later in the life course (OR=1.004). These estimates remained virtually unchanged after adjusting for individual-level risk factors. Inclusion of the neighborhood and

individual measures explained approximately 5.6% in baseline levels of current drinking status and 14.5% in change in current drinking status over time.

For monthly alcohol consumption, neighborhood disorder was associated with greater consumption at baseline (b=0.111), slower initial growth (b=-0.038), and less of a drop in consumption later on (b=0.002) in the unadjusted models. Neighborhood disadvantage was not associated with alcohol consumption at baseline in the unadjusted models, though it was associated with a slower initial growth (b=-0.058) and slower decline later on (b=0.003). Again, the inclusion of individual level and other important covariates did not substantively change the results from the unadjusted models with the exception that neighborhood disadvantage became significantly related to initial status in monthly consumption (b=0.162) and the association for neighborhood disorder and initial status became slightly stronger (b=0.127). Overall, the inclusion of these risk factors explained 4.6% in initial levels of monthly alcohol consumption and 14.6% of the variance in the change over time.

Finally, all three aspects of neighborhoods considered here were important for trajectories of heavy drinking in the unadjusted models. Neighborhood disadvantage was again only associated with linear (b=-0.022) and quadratic (b=0.001) growth, and greater neighborhood disorder was associated with greater levels of heavy drinking at baseline (b=0.05), slower growth in heavy drinking (b=-0.013), and a slower decline later on (b=0.001). However, where neighborhood advantage was not associated with being a current drinker or consumption, it was associated with lower initial levels (b=-0.057), a faster growth (b=0.017), and a steeper decline (b=-0.001) in heavy drinking. Again, these estimates were only slightly attenuated after adjusting for other covariates. These risk factors explained 2.9% in initial levels of alcohol consumption and 8.4% of the variance in the linear change in heavy drinking.

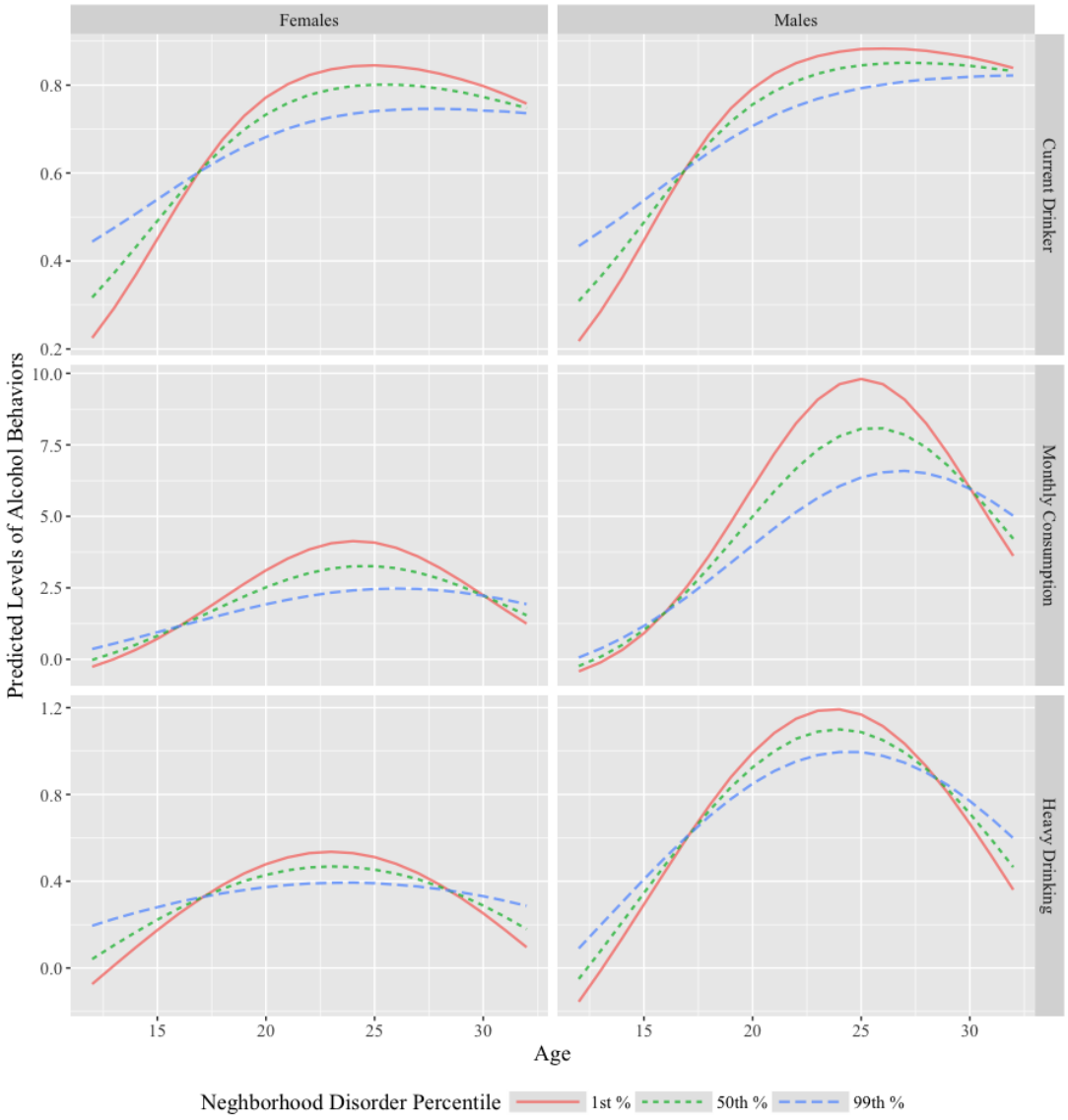
Table 2: Generalized Linear and Linear Mixed-Models for Change in Alcohol Behaviors

		Unadjusted Models			Adjusted Models		
		OR/b	95% CI		OR/b	95% CI	
Current Drinking Status							
Age	I	**0.258**	0.220	0.303	**0.344**	0.251	0.472
	S	**1.590**	1.525	1.657	**1.603**	1.525	1.685
	Q	**0.989**	0.986	0.991	**0.990**	0.987	0.993
Neighborhood Disadvantage	I	0.901	0.697	1.165	1.206	0.930	1.565
	S	**0.930**	0.875	0.988	**0.930**	0.875	0.988
	Q	1.002	0.999	1.005	1.002	0.999	1.005
Neighborhood Advantage:	I	1.004	0.830	1.214	1.041	0.865	1.252
	S	1.012	0.963	1.064	1.013	0.965	1.065
	Q	1.000	0.998	1.003	1.000	0.998	1.003
Neighborhood Disorder	I	**1.426**	1.124	1.809	**1.430**	1.126	1.818
	S	**0.908**	0.856	0.963	**0.914**	0.862	0.969
	Q	**1.004**	1.001	1.007	**1.003**	1.001	1.006
Monthly Consumption							
Age	I	**-0.137**	-0.181	-0.093	-0.069	-0.184	0.046
	S	**0.298**	0.284	0.312	**0.363**	0.344	0.382
	Q	**-0.011**	-0.012	-0.011	**-0.013**	-0.014	-0.012
Neighborhood Disadvantage	I	0.044	-0.024	0.113	**0.162**	0.086	0.238
	S	**-0.058**	-0.080	-0.037	**-0.057**	-0.078	-0.035
	Q	**0.003**	0.002	0.004	**0.003**	0.002	0.004
Neighborhood Advantage:	I	-0.038	-0.101	0.025	-0.011	-0.086	0.064
	S	0.017	-0.004	0.038	0.016	-0.004	0.036
	Q	0.000	-0.001	0.001	0.000	-0.001	0.000
Neighborhood Disorder	I	**0.111**	0.043	0.178	**0.127**	0.056	0.198
	S	**-0.038**	-0.058	-0.019	**-0.039**	-0.058	-0.020
	Q	**0.002**	0.001	0.003	**0.002**	0.001	0.003
Heavy Drinking							
Age	I	-0.004	-0.026	0.018	0.052	-0.008	0.112
	S	**0.097**	0.091	0.104	**0.132**	0.123	0.142
	Q	**-0.004**	-0.004	-0.004	**-0.006**	-0.006	-0.005
Neighborhood Disadvantage	I	0.007	-0.028	0.042	0.051	0.014	0.088
	S	**-0.022**	-0.031	-0.012	**-0.021**	-0.03	-0.011
	Q	**0.001**	0.001	0.001	**0.001**	0.000	0.001
Neighborhood Advantage:	I	**-0.057**	-0.09	-0.025	**-0.041**	-0.079	-0.003
	S	**0.017**	0.006	0.028	**0.017**	0.006	0.028
	Q	**-0.001**	-0.001	0.000	**-0.001**	-0.001	0.000
Neighborhood Disorder	I	**0.050**	0.019	0.081	**0.053**	0.02	0.086
	S	**-0.013**	-0.022	-0.004	**-0.014**	-0.023	-0.004

	Q	**0.001**	0.000	0.001	**0.001**	0.000	0.001

Estimates reflect OR for Current Drinking Status and b for both Monthly Consumption and Heavy Drinking. Adjusted models control for all individual-level and additional covariates on initial status. Sex was included on initial status and change over time. Bolded b/OR = $p < .05$. I = Intercept; S = Linear Slope; Q = Quadratic Slope. Current Drinking Status: $N = 18{,}710$; Observations = 60,577; Monthly Consumption: $N = 18{,}687$; Observations = 59,667; Heavy Drinking: $N = 18{,}736$; Observations = 60,813.

Figure 2 presents the predicted probabilities (for current drinker status) and values (for consumption and heavy drinking) from the fully adjusted models in Table 2. We focus here on neighborhood disorder because it was the most consistent association across each alcohol behavior. Results are presented by sex, across neighborhood disorder values at the 1st, 50th, and 99th percentiles. For each alcohol behavior, we see a similar pattern where individuals from high disorder neighborhoods start with higher levels, only to be passed by their counterparts in low disorder neighborhoods during young adulthood. While it is difficult to determine past the range of the current data, it appears that individuals from high disorder neighborhoods do not see a similar drop in these behaviors during adulthood. These visualizations of model results demonstrate that early exposure to neighborhood disorder has implications for alcohol related behaviors across the early life course.



Discussion

Our goal was to extend research of neighborhoods and alcohol behaviors into a life course framework that examined the relationship between early-life neighborhood conditions and

Figure SEQ Figure * ARABIC 2: Predicted Change in Alcohol Behaviors from Ages 12 to 32 by Neighborhood Disorder and Sex

Figures depict the predicted values and probabilities for alcohol behaviors from best fitting models across sex and age. Neighborhood disorder was fixed at the 1st, 50th, and 99th percentiles. All other covariates were set to zero. Predicted values were back transformed into their original metric.

trajectories of varying stages in severity of alcohol use/misuse. We focused on whether neighborhood socioeconomic conditions (advantage and disadvantage), and neighborhood social

context (disorder) were related to these trajectories above and beyond proximal risk factors. Because these aspects of neighborhood context are thought to shape the conditions that influence alcohol misuse, specifically reduced social control and increased exposure to psychosocial stressors (Hill and Maimon, 2013, Boardman et al., 2001), they are of primary importance.

Overall, each aspect of neighborhoods considered independently contributed to change in one or more of the alcohol behaviors above and beyond proximal risk factors. While recent systematic reviews have found ambiguous results pertaining to the relationship between neighborhood characteristics and alcohol use (Jackson et al., 2014, Algren et al., 2015), we found consistent results in the current analyses. The most consistent finding across each alcohol behavior was the relationship with neighborhood disorder. Individuals from more disordered neighborhoods were at greater initial risk of being a drinker, drinking greater quantities of alcohol in a 30-day period, and having more heavy drinking days per month. However, neighborhood disorder was also associated with a both a slower initial growth and later decline in each of these alcohol behaviors. While those from highly disordered neighborhoods never reached similar levels of alcohol consumption or heavy drinking seen in neighborhoods with lower disorder, they did not see the same drop in alcohol behaviors in young adulthood experienced by their peers in from lower disorder neighborhoods. Neighborhood disadvantage was associated with a slower increase in each alcohol behavior, and a slower decline in later consumption and heavy drinking. Neighborhood advantage was related to lower initial levels of heavy drinking, followed by a more rapid increase across adolescence and decrease during young adulthood.

The independent associations between each of these aspects of neighborhood context and various levels of alcohol use demonstrate the importance of multiple domains of neighborhood

characteristics in relation to different alcohol behaviors across the early life course. These independent contributions of each may also explain why previous research has found little consistent evidence (Jackson et al., 2014, Algren et al., 2015), especially if researchers are using index of neighborhood SES that include both measures of advantage and disadvantage. Our analyses highlight the utility of examining these constructs separately.

Adverse neighborhood conditions experienced during adolescence place individuals at greater initial risk of drinking and misusing alcohol. While there is still debate over whether early initiation could place individuals at increased risk of developing an alcohol use disorder (AUD) later in life or whether this just reflects some common underlying risky predisposition towards problem use (Maimaris and McCambridge, 2014, Prescott and Kendler, 1999), it is clear in the current analysis that neighborhood disorder places individuals at greater risk for use and misuse use at a much earlier point in the life course.

The slower growth in these behaviors into early adulthood for those from both disadvantaged and disordered neighborhoods may reflect the lower likelihood of these individuals to finish high school (Harding, 2009, Harding, 2003), and eventually enter social contexts where alcohol use and heavy drinking are normal, such as college (O'Malley and Johnston, 2002). However, though individuals from disadvantaged neighborhoods may be less likely to drink heavily, recent evidence suggests that they experience more alcohol related problems in young adulthood, in part because of the effect of neighborhood disadvantage has on scholastic achievement and educational attainment (Karriker-Jaffe et al., 2018). Identifying mechanisms through which exposure to adverse neighborhood conditions influences patterns of alcohol misuse will be an important next step in developing our understanding of how these early life exposures operate.

Additionally, it is not only negative aspects of neighborhood conditions that matter. Because neighborhood disadvantage and advantage were examined independently, we were able to estimate the influence of each on the alcohol behaviors considered. While advantage was not related to either current drinking status or consumption, it was related to lower levels of heavy drinking in early adolescence. The increased likelihood of entering college may also explain why those from neighborhoods with more advantage experienced a steeper increase in heavy drinking, similar to previous cross sectional findings (Slutske et al., 2016, Karriker-Jaffe, 2011). And while individuals from these neighborhoods saw a more severe increase during adolescence, they also experienced a faster decline during young adulthood.

Taken as a whole, these results demonstrate the changing importance of various aspects of neighborhood conditions in relation to different levels of severity in alcohol use across the early life course. While adverse conditions may place individuals at risk early on, coming from more a stable neighborhood may propel individuals from advantaged backgrounds into situations where risky drinking is common. Overall, there is consistent evidence that those in higher SES positions drink more frequently (Collins, 2016). Though it is beyond the scope of the age range in the current data, it appears as though individuals from lower disorder/more advantaged neighborhoods experience a drop in alcohol behaviors that those from highly disordered neighborhoods do not experience. Because trajectories of use and heavy use tend to decline across mid-to-late life (Karlamangla et al., 2006, Britton et al., 2015) future waves of Add Health data will allow us to examine whether the these trajectories continue to diverge as individuals move into middle and later life, an important goal in determining the early life origins of later life health disparities.

Results in these analyses extend our current understanding of neighborhoods and alcohol misuse in several key ways. First, it extends previous longitudinal work on neighborhoods and other externalizing behaviors (Karriker-Jaffe et al., 2011, Karriker-Jaffe et al., 2013, Wheaton and Clarke, 2003) to the importance neighborhood conditions have in relation to long-term patterns of alcohol use across formative years and into adulthood. Second, it demonstrates that neighborhood social context has a more consistent relationship with alcohol behaviors than socioeconomic conditions such as neighborhood disadvantage. Efforts at improving the social contexts within neighborhoods, such as combating neighborhood disorder and increasing a neighborhood's ability to mobilize resources and reestablish mechanisms of social control (collective efficacy) would likely improve the health residents in part by the way it influences alcohol use. This is not to say that these socioeconomic components are not important, as these largely determine the social context within a neighborhood (Sampson et al., 1997). Recent work has shown that much of the impact that neighborhood disadvantage has on early adolescent drinking is mediated through these social conditions (Jackson et al., 2016). Therefore, we must address the fundamental causes that lead to neighborhood decline in the first place if we are to reduce health disparities (Cerdá et al., 2014). Finally, this work demonstrates the independent influence of neighborhood disadvantage and advantage. While previous research has found neighborhood SES to be positively related to different types of alcohol misuse (Slutske et al., 2016), they assessed neighborhood SES as a single dimension. Future work should continue to examine the influence of these distinct, but related factors.

Several important limitations should be considered when interpreting these results. First, causal inference is difficult because of Add Health's observational design. This is especially difficult in the study of neighborhoods where there is the possibility of selection into

neighborhoods based on certain characteristics of the neighborhood or the individual. While respondents were less likely to have control over their current neighborhood during adolescence, selection was still possible given that alcohol use/misuse is moderately heritable (Verhulst et al., 2015) and genetic liability could be the reason both parents and children selected into their current neighborhood. However, there is growing evidence from other quasi-experimental designs that neighborhoods do have some causal effect on a variety of outcomes (Chetty et al., 2016). Reexamination of large-scale relocation initiatives has shown moving to a more advantaged neighborhood is beneficial for mental health when we consider conditions of surrounding neighborhoods (Graif et al., 2016).

Another important limitation reflects the number of waves of information on neighborhood characteristics. The current analysis was limited to neighborhoods during baseline data collection. While though there is some evidence that a single point measure is a good proxy for children's neighborhood environment over time (Kunz et al., 2003) and that neighborhood of origin is more consequential than concurrent neighborhood (Wheaton and Clarke, 2003), our current analysis is limited because we are unable to evaluate the influence of *changing* one's neighborhood has on alcohol misuse, or vice-versa. Future research should incorporate time-varying measures of neighborhood characteristics, as there are different effects for single and cumulative exposures (Cerdá et al., 2010). Ideally, the initial measure of neighborhood conditions would come from even earlier than adolescence.

Neighborhood context has significant implications for alcohol use. The relationship is not straightforward in that more adverse neighborhood conditions always place individuals at greater risk of using and misusing alcohol. Drawing on longitudinal data from a nationally representative study, we demonstrated that early to exposure to adverse neighborhood conditions resulted in

earlier and heavier alcohol use. However, their counterparts from more stable, advantaged neighborhoods soon eclipsed alcohol behaviors of individuals from adverse neighborhood contexts. These individuals from more stable neighborhoods also experienced a sharp decline in alcohol behaviors during early adulthood that those from highly disordered neighborhoods did not experience. Future research should determine if these patterns persist into middle and later life.

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References

AARNOUDSE-MOENS, C. S. H., WEISGLAS-KUPERUS, N., VAN GOUDOEVER, J. B. & OOSTERLAAN, J. 2009. Meta-Analysis of Neurobehavioral Outcomes in Very Preterm and/or Very Low Birth Weight Children. *Pediatrics,* 124**,** 717.

AHERN, J., MARGERISON-ZILKO, C., HUBBARD, A. & GALEA, S. 2013. Alcohol Outlets and Binge Drinking in Urban Neighborhoods: The Implications of Nonlinearity for Intervention and Policy. *American Journal of Public Health,* 103**,** e81 - e87.

AKAIKE, H. 1974. A new look at the statistical model identification. *IEEE transactions on automatic control,* 19**,** 716-723.

ALGREN, M. H., BAK, C. K., BERG-BECKHOFF, G. & ANDERSEN, P. T. 2015. Health-Risk Behaviour in Deprived Neighbourhoods Compared with Non-Deprived Neighbourhoods: A Systematic Literature Review of Quantitative Observational Studies. *PLOS ONE,* 10**,** e0139297.

ANESHENSEL, C. S. & SUCOFF, C. A. 1996. The neighborhood context of adolescent mental health. *Journal of health and social behavior,* 37**,** 293-310.

BARR, P. B., SALVATORE, J. E., MAES, H. H., ALIEV, F., LATVALA, A., VIKEN, R. J., ROSE, R. J., KAPRIO, J. & DICK, D. M. 2016. Education and alcohol use: A study of gene-environment interaction in young adulthood. *Social Science & Medicine,* 162**,** 158-167.

BEARMAN, P. S. & MOODY, J. 2004. Suicide and Friendships Aong American Adolescents. *American Journal of Public Health,* 94**,** 89-95.

BOARDMAN, J. D., FINCH, B. K., ELLISON, C. G., WILLIAMS, D. R. & JACKSON, J. S. 2001. Neighborhood disadvantage, stress, and drug use among adults. *Journal of health and social behavior***,** 151-165.

BRECHWALD, W. A. & PRINSTEIN, M. J. 2011. Beyond Homophily: A Decade of Advances in Understanding Peer Influence Processes. *Journal of Research on Adolescence,* 21**,** 166-179.

BRESLAU, J., LANE, M., SAMPSON, N. & KESSLER, R. C. 2008. Mental disorders and subsequent educational attainment in a US national sample. *Journal of Psychiatric Research,* 42**,** 708--716.

BRITTON, A., BEN-SHLOMO, Y., BENZEVAL, M., KUH, D. & BELL, S. 2015. Life course trajectories of alcohol consumption in the United Kingdom using longitudinal data from nine cohort studies. *BMC Med,* 13**,** 47.

CERDÁ, M., DIEZ-ROUX, A. V., TCHETGEN, E. T., GORDON-LARSEN, P. & KIEFE, C. 2010. The Relationship Between Neighborhood Poverty and Alcohol Use: Estimation by Marginal Structural Models. *Epidemiology,* 21**,** 482-489.

CERDÁ, M., TRACY, M., AHERN, J. & GALEA, S. 2014. Addressing Population Health and Health Inequalities: The Role of Fundamental Causes. *American Journal of Public Health,* 104**,** S609 - S619.
CHEN, P. & JACOBSON, K. C. 2012. Developmental trajectories of substance use from early adolescence to young adulthood: gender and racial/ethnic differences. *Journal of Adolescent Health,* 50**,** 154-63.
CHETTY, R., HENDREN, N. & KATZ, L. F. 2016. The Effects of Exposure to Better Neighborhoods on Children: New Evidence from the Moving to Opportunity Experiment. *American Economic Review,* 106**,** 855-902.
COLLINS, S. E. 2016. Associations between socioeconomic factors and alcohol outcomes. *Alcohol research: current reviews,* 38**,** 83.
DICK, D. M., ROSE, R. J., VIKEN, R. J., KAPRIO, J. & KOSKENVUO, M. 2001. Exploring gene-environment interactions: Socioregional moderation of alcohol use. *Journal of Abnormal Psychology,* 110**,** 625-632.
FITZMAURICE, G. M., LAIRD, N. M. & WARE, J. H. 2012. *Applied longitudinal analysis*, Wiley.
GFROERER, J. C. & TAN, L. L. 2003. Substance Use Among Foreign-Born Youths in the United States: Does the Length of Residence Matter? *American Journal of Public Health,* 93**,** 1892-1895.
GRAIF, C., ARCAYA, M. C. & DIEZ ROUX, A. V. 2016. Moving to opportunity and mental health: Exploring the spatial context of neighborhood effects. *Soc Sci Med,* 162**,** 50-8.
HARDING, D. J. 2003. Counterfactual Models of Neighborhood Effects: The Effect of Neighborhood Poverty on Dropping Out and Teenage Pregnancy. *American Journal of Sociology,* 109**,** 676-719.
HARDING, D. J. 2009. Collateral Consequences of Violence in Dsadvantaged Neighborhoods. *Social Forces,* 88**,** 757-784.
HARRIS, K. M. 2009. The National Longitudinal Study of Adolescent to Adult Health (Add Health), Waves I & II, 1994–1996; Wave III, 2001–2002; Wave IV, 2007-2009 [machine-readable data file and documentation]. Chapel Hill, NC: Carolina Population Center, University of North Carolina at Chapel Hill.
HILL, T. D. & ANGEL, R. J. 2005. Neighborhood disorder, psychological distress, and heavy drinking. *Social Science & Medicine,* 61**,** 965-975.
HILL, T. D. & MAIMON, D. 2013. Neighborhood Context and Mental Health. *In:* ANESHENSEL, C. S., PHELAN, J. C. & BIERMAN, A. (eds.) *Handbook of the Sociology of Mental Health.* Dordrecht: Springer Netherlands.
JACKSON, N., DENNY, S. & AMERATUNGA, S. 2014. Social and socio-demographic neighborhood effects on adolescent alcohol use: A systematic review of multi-level studies. *Social Science & Medicine,* 115**,** 10-20.
JACKSON, N., DENNY, S., SHERIDAN, J., ZHAO, J. & AMERATUNGA, S. 2016. The role of neighborhood disadvantage, physical disorder, and collective efficacy in adolescent alcohol use: a multilevel path analysis. *Health Place,* 41**,** 24-33.
JONES-WEBB, R. & KARRIKER-JAFFE, K. J. 2013. Neighborhood Disadvantage, High Alcohol Content Beverage Consumption, Drinking Norms, and Drinking Consequences: A Mediation Analysis. *Journal of Urban Health : Bulletin of the New York Academy of Medicine,* 90**,** 667-684.

KARLAMANGLA, A., ZHOU, K., REUBEN, D., GREENDALE, G. & MOORE, A. 2006. Longitudinal trajectories of heavy drinking in adults in the United States of America. *Addiction,* 101**,** 91-9.
KARRIKER-JAFFE, K. J. 2011. Areas of disadvantage: A systematic review of effects of area-level socioeconomic status on substance use outcomes. *Drug and Alcohol Review,* 30**,** 84-95.
KARRIKER-JAFFE, K. J., FOSHEE, V. A. & ENNETT, S. T. 2011. Examining how neighborhood disadvantage influences trajectories of adolescent violence: a look at social bonding and psychological distress. *J Sch Health,* 81**,** 764-73.
KARRIKER-JAFFE, K. J., FOSHEE, V. A., ENNETT, S. T. & SUCHINDRAN, C. 2013. Associations of neighborhood and family factors with trajectories of physical and social aggression during adolescence. *J Youth Adolesc,* 42**,** 861-77.
KARRIKER-JAFFE, K. J., LÖNN, S. L., COOK, W. K., KENDLER, K. S. & SUNDQUIST, K. 2018. Chains of risk for alcohol use disorder: Mediators of exposure to neighborhood deprivation in early and middle childhood. *Health & Place,* 50**,** 16-26.
KARRIKER-JAFFE, K. J., ZEMORE, S. E., MULIA, N., JONES-WEBB, R., BOND, J. & GREENFIELD, T. K. 2012. Neighborhood Disadvantage and Adult Alcohol Outcomes: Differential Risk by Race and Gender. *Journal of Studies on Alcohol and Drugs,* 73**,** 865-873.
KENDLER, K. S., PRESCOTT, C. A., MYERS, J. & NEALE, M. C. 2003. The structure of genetic and environmental risk factors for common psychiatric and substance use disorders in men and women. *Archives of General Psychiatry,* 60**,** 929-937.
KERR, W. C., YE, Y., GREENFIELD, T. K., WILLIAMS, E., LOWN, E. A. & LUI, C. K. 2016. Early Life Health, Trauma and Social Determinants of Lifetime Abstention from Alcohol. *Alcohol and Alcoholism,* 51**,** 576-583.
KUIPERS, M. A. G., VAN POPPEL, M. N. M., VAN DEN BRINK, W., WINGEN, M. & KUNST, A. E. 2012. The association between neighborhood disorder, social cohesion and hazardous alcohol use: A national multilevel study. *Drug and Alcohol Dependence,* 126**,** 27-34.
KUNZ, J., PAGE, M. E. & SOLON, G. 2003. Are point-in-time measures of neighborhood characteristics useful proxies for children's long-run neighborhood environment? *Economics Letters,* 79**,** 231-237.
LIVINGSTON, M. 2011. Alcohol outlet density and harm: comparing the impacts on violence and chronic harms. *Drug Alcohol Rev,* 30**,** 515-23.
MAIMARIS, W. & MCCAMBRIDGE, J. 2014. Age of first drinking and adult alcohol problems: systematic review of prospective cohort studies. *J Epidemiol Community Health,* 68**,** 268-74.
MUJAHID, M. S., DIEZ ROUX, A. V., MORENOFF, J. D. & RAGHUNATHAN, T. 2007. Assessing the measurement properties of neighborhood scales: from psychometrics to ecometrics. *Am J Epidemiol,* 165**,** 858-67.
MULIA, N. & KARRIKER-JAFFE, K. J. 2012. Interactive Influences of Neighborhood and Individual Socioeconomic Status on Alcohol Consumption and Problems. *Alcohol and Alcoholism,* 47**,** 178-186.
O'MALLEY, P. M. & JOHNSTON, L. D. 2002. Epidemiology of alcohol and other drug use among American college students. *Journal of Studies on Alcohol, Supplement***,** 23-39.

PRESCOTT, C. A. & KENDLER, K. S. 1999. Age at First Drink and Risk for Alcoholism: A Noncausal Association. *Alcoholism: Clinical and Experimental Research,* 23**,** 101-107.
RAUDENBUSH, S. W. & SAMPSON, R. J. 1999. Ecometrics: Toward a Science of Assessing Ecological Settings, with Application to the Systematic Social Observation of Neighborhoods. *Sociological Methodology,* 29**,** 1-41.
ROMLEY, J. A., COHEN, D., RINGEL, J. & STURM, R. 2007. Alcohol and Environmental Justice: The Density of Liquor Stores and Bars in Urban Neighborhoods in the United States. *Journal of Studies on Alcohol and Drugs,* 68**,** 48-55.
ROSENBERG, M. 1965. *Society and the Adolescent Self-Image,* Princeton, NJ, Princeton University Press
SAMPSON, R. J., RAUDENBUSH, S. W. & EARLS, F. 1997. Neighborhoods and violent crime: a multilevel study of collective efficacy. *Science,* 277**,** 918-24.
SINGER, J. D. & WILLETT, J. B. 2003. *Applied longitudinal data analysis: Modeling change and event occurrence*, Oxford university press.
SLUTSKE, W. S., DEUTSCH, A. R. & PIASECKI, T. M. 2016. Neighborhood Contextual Factors, Alcohol Use, and Alcohol Problems in the United States: Evidence From a Nationally Representative Study of Young Adults. *Alcoholism: Clinical and Experimental Research,* 40**,** 1010-1019.
SOUTH, S. J. & CROWDER, K. D. 1999. Neighborhood Effects on Family Formation: Concentrated Poverty and Beyond. *American Sociological Review,* 64**,** 113-132.
TURNER, H. A., SHATTUCK, A., HAMBY, S. & FINKELHOR, D. 2013. Community disorder, victimization exposure, and mental health in a national sample of youth. *J Health Soc Behav,* 54**,** 258-75.
VERHULST, B., NEALE, M. C. & KENDLER, K. S. 2015. The heritability of alcohol use disorders: a meta-analysis of twin and adoption studies. *Psychological Medicine,* 45**,** 1061-1072.
VON HIPPEL, P. T. 2007. Regression With Missing Y's: An Improved Strategy For Analyzing Multiply Imputed Data. *Sociological Methodology,* 37**,** 83-117.
WHEATON, B. & CLARKE, P. 2003. Space meets time: Integrating temporal and contextual influences on mental health in early adulthood. *American Sociological Review,* 68**,** 680-706.
WILSON, W. J. 2012. *The truly disadvantaged: The inner city, the underclass, and public policy*, University of Chicago Press.
WORLD HEALTH ORGANIZATION 2014. Global status report on alcohol and health, 2014.
YING-CHIH, C., SUSAN, T. E., KARL, E. B. & VANGIE, A. F. 2005. Neighborhood Influences on Adolescent Cigarette and Alcohol Use: Mediating Effects through Parent and Peer Behaviors. *Journal of Health and Social Behavior,* 46**,** 187-204.