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Longitudinal associations of neighborhood socioeconomic characteristics and alcohol availability on drinking: Results from the Multi-ethnic Study of Atherosclerosis (MESA)

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Abstract

Neighborhood socioeconomic characteristics and alcohol availability may affect alcohol consumption, but adequate longitudinal research to support these hypotheses does not exist. We used data from the Multi-Ethnic Study of Atherosclerosis (MESA) (N= 6163) to examine associations of changes in neighborhood socioeconomic status (SES) and alcohol outlet density, with current, weekly, and heavy daily alcohol consumption in hybrid effects models. We also examined whether these associations were moderated by gender, race/ethnicity, and income. Increases in neighborhood SES were associated with decreases in the probability of current alcohol use after adjustment for age, gender, race/ethnicity, individual SES, marital status and time since baseline [probability ratio (PR) per SD increase in neighborhood SES = 0.96, 95% confidence interval (CI) (0.96,0.99)]. Increases in liquor store densities were associated with increases in weekly alcohol consumption [ratio of weekly drinks per SD increase in outlet density= 1.07, 95% CI (1.01,1.05) for men, PR = 1.11, 95% CI (1.01,1.21) for women]. Relationships between current alcohol use and neighborhood SES and between weekly beer consumption and neighborhood SES were generally stronger among those with higher incomes.

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Neighborhood socioeconomic context and the availability of alcohol may be important for understanding patterns of alcohol use over time, and for targeting interventions and policies to reduce harmful alcohol use.

Keywords

Alcohol; neighborhood; alcohol outlet density; socioeconomic status; longitudinal; Multi-ethnic Study of Atherosclerosis

1. Introduction

Alcohol use is a significant health problem that contributes to the burden of premature morbidity and mortality (Mokdad, 2004; Rehm, Greenfield, & Rogers, 2001). Although individual-level risk factors for alcohol use have been well established (Karlamangla, Zhou, Reuben, Greendale, & Moore, 2006; SAMHSA, 2013) they do not fully explain variability in alcohol use, (Fesahazion, Thorpe Jr, Bell, & LaVeist, 2012; Sandro Galea, Nandi, & Vlahov, 2004) suggesting that other factors need to be explored. Neighborhood socioeconomic disadvantage and neighborhood alcohol availability have been investigated as potential contributors to alcohol use and alcohol-related problems (S. Galea, Ahern, Tracy, & Vlahov, 2007; T. A. LaVeist & Wallace Jr, 2000; Pollack, Cubbin, Ahn, & Winkleby, 2005; Katherine P. Theall et al., 2009). Neighborhood disadvantage may contribute to alcohol use through a psychological stress pathway. Disadvantaged neighborhoods are characterized by poverty, unemployment and residential instability, which may expose residents to physical and social stressors including vacancy and deterioration, noise, crime and violence (Aneshensel, 2008). Thus, alcohol may serve as an avoidant coping strategy to mitigate stress due to exposure to stressors in disadvantaged neighborhoods (Conger, 1956; M. L. Cooper, Russell, Skinner, Frone, & Mudar, 1992). Some researchers have found that neighborhood disadvantage is associated with higher rates of heavy alcohol use (M. Cerdá, Diez-Roux, Tchetgen, Gordon-Larsen, & Kiefe, 2010; S. Galea, et al., 2007), but with a lower probability of using alcohol (K. J. Karriker-Jaffe et al., 2012; Nina Mulia, Ye, Zemore, & Greenfield, 2008). Others have found no relationship between neighborhood socioeconomic context and alcohol use (SAMHSA, 2013; Shimotsu et al., 2013), or that neighborhood disadvantage is associated with less alcohol use (Fone, Farewell, White, Lyons, & Dunstan, 2013; Kuipers et al., 2013; Pollack, et al., 2005). Research is largely confined to cross-sectional studies, limiting our ability to draw causal inferences, and to study patterns in alcohol use in response to changes in the neighborhood context. In the only longitudinal study of neighborhood socioeconomic status (SES) and alcohol use in an adult population, Cerdá et al. found that a unit increase in cumulative neighborhood poverty, was associated with a 60% increase in the odds of binge drinking, and a 53% increase in weekly alcohol consumption (M. Cerdá, et al., 2010).

Alcohol availability is another neighborhood feature (often associated with neighborhood disadvantage) (T. LaVeist & Wallace, 2000; Pollack, et al., 2005), that may influence individuals' alcohol use. Researchers have found cross-sectional associations between the density of alcohol outlets near residents' homes and alcohol use. Higher alcohol outlet density has been associated with harmful social norms related to alcohol use (R. Scribner, 2007), violence (R. A. Scribner, MacKinnon, & Dwyer, 1995), and crime (Toomey et al., 2012), increased alcohol use, and alcohol-related problems (Livingston, Chikritzhs, & Room, 2007; Katherine P. Theall, et al., 2009; K.D. Truong & Sturm, 2009). Research on neighborhood access to alcohol and individual-level alcohol use has also been mainly confined to cross-sectional studies. We identified only three longitudinal studies of alcohol outlet density and alcohol consumption in adults, suggesting that increasing alcohol outlet density is a risk factor for alcohol use (H. L. Cooper et al., 2013; Halonen et al., 2013; Picone, MacDougald, Sloan, Platt, & Kertesz, 2010). More research is necessary to understand how alcohol availability might affect different types and patterns of alcohol use over time, and how demographic factors influence these relationships.

Relationships between changes in neighborhood factors and changes in alcohol use over time are likely to depend on individual-level factors like gender (Fone, et al., 2013; K. J. Karriker-Jaffe, et al., 2012; Matheson, White, Moineddin, Dunn, & Glazier, 2012), race/ethnicity (K. J. Karriker-Jaffe, et al., 2012) and income (N. Mulia & Karriker-Jaffe, 2012), yet most previous research has not addressed these factors. Men and women perceive and react to their neighborhoods differently, (Kershaw, Albrecht, & Carnethon, 2013; Matheson, White, Moineddin, Dunn, & Glazier, 2010) which could be at least partially associated with differences in alcohol use by gender (Holmila & Raitasalo, 2005; Nolen-Hoeksema, 2004). The relationship between neighborhood context and alcohol use could also vary by race/ethnicity, as racial/ethnic minorities are likely to have greater exposure to stressors in their neighborhoods than whites, and may use alcohol to cope with this added burden (Luisa N Borrell et al., 2010; Luisa N. Borrell, Kiefe, Diez-Roux, Williams, & Gordon-Larsen, 2012). Income may also moderate the association of neighborhood context and alcohol use (N. Mulia & Karriker-Jaffe, 2012).

Older adults may have greater exposure to their neighborhood environment than younger adults as limitations in mobility, cognitive capacity, and driving often restrict older adults to their more immediate neighborhood (Balfour & Kaplan, 2002; Cagney, Browning, & Wen, 2005). Researchers have consistently found that neighborhood SES is associated with health in older populations (Yen, Michael, & Perdue, 2009). Despite declines in alcohol use as people age (Zhang et al., 2008), the risks of using alcohol increase (Merrick et al., 2008; Oslin, 2000; Sorocco & Ferrell, 2006), thus older adults represent a vulnerable population.

We used longitudinal data from the Multi-Ethnic Study of Atherosclerosis (MESA) to examine associations of changes in neighborhood SES and alcohol outlet density, with current, weekly, and heavy daily alcohol consumption over time. Studies that include contextual influences on drinking rarely assess multiple drinking outcomes and types of alcohol, and do not examine the extent to which neighborhood factors are differentially related to specific types of use, which may be differentially related to environmental factors (N. Mulia & Karriker-Jaffe, 2012). We also examined whether these associations differed by gender, race/ethnicity, and income.

2. Methods

2.1 Study population

The Multi-ethnic Study of Atherosclerosis (MESA) is a population-based, prospective cohort study of cardiovascular disease. MESA participants were recruited from six sites in the US (Forsyth County, NC; New York City, NY; Baltimore, MD; St Paul, MN; Chicago, IL; and Los Angeles, CA). The baseline assessment was conducted from 2000 to 2002 (exam 1), with four follow-up assessments conducted at approximately 1.5-2 year intervals (exams 2 to 5) (D.E. Bild et al., 2002). The original cohort included 6,814 individuals from 45 to 84 years who were free of clinical cardiovascular disease. The sample was racially and ethnically diverse (38% white, 28% African American, 22% Hispanic, 12% Asian). The study was approved by the Institutional Review Board at each site, and all participants gave written informed consent. Of the 6,814 participants, 6,191 participated in the MESA Neighborhood Study, providing consent to geocode their home address; 28 were dropped due to inaccurate geocoding leaving 6,163 individuals for the analysis.

2.2 Individual measures

Alcohol use outcomes—Alcohol use outcomes included current, weekly, and heaviest daily use. Current alcohol use was assessed at all exams by asking participants if they “presently drink alcoholic beverages”; if negative, all other drinking questions for that exam were skipped. Information on current alcohol use was available for 6,123 participants at baseline. Current drinkers provided information on weekly and highest daily alcohol use. Weekly alcohol use was assessed in all exams, although the question was asked differently in the first exam so analyses were restricted to exams 2-5 (N=6020). Participants were asked to report the average number of drinks of beer, red wine, white wine, and liquor they typically consumed per week. Weekly values for red and white wine were summed. Weekly alcohol use was assessed as a count outcome for each type of alcohol use (beer, wine, liquor) and as total weekly alcohol use. Heaviest daily alcohol use was assessed in exams 1-3 by asking participants to report the largest number of drinks they consumed in a single day in the past month. We operationalized heaviest daily use as a count outcome (N=6132).

Neighborhood measures—Neighborhood SES was assessed using data from the 2000 US Census and the American Community Survey (ACS) 2005-2009, and 2007-2011 estimates. Data was linked to MESA participant data by census tract using Census and ACS estimates for the closest time period. A summary SES index was constructed by factor analysis of six indicators of neighborhood-level SES: median household income, household wealth (median value of housing units and percent of households with interest, dividend, or net rental income), education, and percent of employed persons 16 and older in executive, managerial, or professional occupation (A. Diez Roux et al., 2001). Several items were log transformed to improve the distribution, and the items were standardized and summed to create the neighborhood SES measure. An increasing score indicates more socioeconomic advantage (Range −19.4-14.8). Neighborhood SES was included as a continuous variable in all models and results are reported for one standard deviation (SD) changes in neighborhood SES (coefficients were multiplied by the value for one SD of the continuous neighborhood

SES measure, and confidence intervals were similarly adjusted) due to the wide range of SES values.

Information on alcohol outlets was obtained from the National Establishment Time Series (NETS) data from Walls and Associates using Standard Industrial Classification (SIC) codes to identify liquor stores and on-site drinking places (restaurants and bars). Alcohol outlet densities were created for 0.5-5 mile buffers around participants' homes for liquor stores and on-site drinking places separately. A one mile buffer Silverman kernel (ArcGIS kernel density function)(Silverman, 1986) was used in this analysis, as it has been found to result in the largest effect sizes in other studies (Schonlau et al., 2008; Richard A. Scribner, Cohen, & Fisher, 2000), and is a reasonable walking and driving distance. Kernel densities, unlike simple densities, assign greater weight to alcohol outlets that are closer to participants' homes (Silverman, 1986). Densities were created for liquor stores (Range 0-29.42) and on-site drinking places (referred to as bar density in text) (Range 0-56.97) each year from 2000-2011, and were linked to the corresponding year of individual MESA data. All alcohol outlet density measures were included as continuous variables in the models and results are reported for one SD changes in outlet density as described above for neighborhood SES.

Covariates—Time-invariant covariates assessed at baseline included age, gender, study site, race/ethnicity, and education. Race/ethnicity was captured in four categories: White, Chinese American, Black/African American or Hispanic. Participants reported their highest level of education based on nine response choices ranging from "no schooling" to "graduate or professional". A continuous variable was created to assess total years of education by assigning each participant the interval midpoint of the selected category (e.g., grades 9-11 would be assigned 10 years of education).

Time-varying covariates included marital status, employment status, income and years since baseline. Marital status (single, married/living with partner) was assessed at baseline and exams 3-5. Data for exam 2 were imputed from exams 1 or 3 based on closest date. Employment status was assessed at all exams. Participants chose from 10 employment categories (e.g., employed full time, part time, unemployed), and a binary job status measure was created to characterize individuals as currently working or not working. Income was assessed at baseline, Exams 1-3 and 5. Participants selected their gross family income over the past year by choosing from 13 categories that ranged from less than $5,000 to over $100,000. A continuous measure of annual income was created by assigning participants the interval midpoint of the selected category. Because income was not assessed at Exam 4 we used income values (N=5,671) from participants' income data at the closest exam date. In analyses income is interpreted per $10,000 increase.

Analyses of current drinking included a total of 6123 participants with non-missing data at baseline, of which 4128 participants had data for all five visits, 1288 had information for 4 visits, 421 for three visits and 226 for two visits. Analyses of total number of drinks per week included a total of 6020 participants with non-missing data at exam 2 of which 4235 had data for all four visits, 1283 provided data for at least 3 visits and 383 for at least 2 visits. Analyses of highest number of drinks consumed included a total of 6132 participants with non-missing data at exam 2 of which 5667 provided data on all three visits and 496 provided data for at least 2 visits.

2.3 Analyses

Descriptive analyses were conducted to examine the characteristics of the participants at each exam. Associations of each of the neighborhood predictors with alcohol use were examined in separate models. The type of alcohol outlet (on-site/bars vs. off-site/liquor stores) may have different effects on alcohol use (Connor, Kypri, Bell, & Cousins, 2011; Khoa D Truong & Sturm, 2007), so we examined them separately. We ran gender-stratified analyses for all outcomes.

To investigate how change in exposures are associated with changes in alcohol use we employed hybrid effects models (Allison, 2009). Hybrid effects models combine features of fixed and random effects models. They are more flexible than fixed effects models because they allow estimation of coefficients for time invariant predictors. At the same time, they have the advantage of fixed effects models in that they allow estimation of associations of within person changes in predictors with within person changes in outcomes, tightly controlling for known and unknown time invariant characteristics. This is accomplished by including a person-level mean for each time varying predictor (which captures between person effects) and a measure of the deviation of each observation from the person specific mean (which captures the more causally relevant within person effects). Hybrid models account for correlations between observations on the same person via the inclusion of random effects. Hybrid models are a better choice than fixed effects models for negative binomial count models, as conditional maximum likelihood estimators are not available for fixed effects models for these types of outcomes, making hybrid models a good alternative (Allison, 2009).

To build the hybrid models we first specified a random effects model that included the time invariant predictors, person-level means for each time varying predictor, person-level deviations from this mean for each exam, and time (specified as days from the baseline exam). The model also included interactions of the time invariant covariates with time, which were retained in the final models only if they were significant (p-value <0.05). We compared each person-level mean coefficient to the corresponding person-level deviation coefficient for all time-varying predictors using a Wald Test(Allison, 2009). If the null hypothesis that both coefficients were equal was not rejected, we concluded that there was no evidence that within person and between-person associations differed and hence that the estimate based on the between-person associations (which can be estimated more precisely when within person variation is small) was not confounded by unmeasured time invariant person specific characteristics. For these variables we retained only the time varying measure (rather than the person specific mean and the deviation) and derived an estimate of the association of interest from this coefficient. When the null hypothesis that both coefficients were equal was rejected we retained the mean and deviation terms and used the coefficient from the deviation term to estimate the association of interest. Estimates derived from the deviation term are noted in the tables. Separate models were fitted for neighborhood SES and for alcohol outlet density. Models for alcohol outlet density controlled for neighborhood SES, as prior research suggests that outlet density is higher in low SES communities (Romley, Cohen, Ringel, & Sturm, 2007). However, because alcohol outlet density may mediate the association of neighborhood SES and alcohol use, it was not included in models of neighborhood SES. After the main effect models we also examined models that included interactions of neighborhood SES and alcohol outlet density with race/ethnicity and income based on our hypotheses. To restrict the number of interactions tested, interactions of total alcohol outlet density (rather than liquor store and bar density separately) with the individual factors were tested.

We modeled current alcohol use using a hybrid Poisson model with robust standard errors to approximate the relative change in the prevalence of alcohol use. Analyses for weekly and heaviest daily alcohol use used a negative binomial regression hybrid effects models to model the log count of drinks per week or highest number of drinks in a month. Coefficients were exponentiated to facilitate interpretation, and represent rate ratios of the number of drinks consumed . These models are appropriate with overdispersed data. All models were adjusted for baseline age, race/ethnicity, study site, income, education, occupation status marital status and time since baseline, as well as significant interactions between fixed covariates and time since baseline. Multilevel models for mixed-effects negative binomial regression (menbreg in Stata version 13) were tested to determine the extent of the variation between neighborhoods, and models for current and heavy daily alcohol use indicated a level-3 variance component of approximately 7% (current use) and 2% (heavy daily use) of the proportion of the variance in alcohol use that can be accounted for by the shared neighborhood context. Between-neighborhood variance was larger in weekly alcohol use models (48%), but the estimates for the coefficients and standard errors in the final models were similar with no substantive differences in interpretation and overall results. Thus models did not account for clustering at the neighborhood level to simplify computational requirements for the analyses and results from the more simple models are therefore reported.

3. Results

Table 1 displays characteristics of the sample over the five exams for all available data at each exam. More men and non-White participants were lost to follow-up between Exams 1 and 5 than women and White participants, although this difference was small. As participants were lost to follow-up, income and education increased. The percentage of people employed and married decreased as individuals aged. The percent of participants currently drinking alcohol ranged from 56% at baseline to 42.6% at the final exam. The mean weekly number of drinks was 2.9 at exam 2 and remained stable over time. On average participants drank 1.5 drinks per day on their heaviest drinking day in the past month at baseline, and this remained constant over the following two exams. Over the study exams the socioeconomic status of neighborhoods improved and alcohol outlet densities around participants' homes increased.

Overall, non-white participants had a lower probability of current alcohol use and lower rates of weekly and heavy daily alcohol use than Whites and racial/ethnic differences in alcohol use were more pronounced for women than for men. In men higher income was associated with heavier daily alcohol use, whereas higher education was associated with a lower number of drinks consumed per week. In women, higher income and education were associated with heavier daily alcohol use and more weekly alcohol (data not shown).

3.1 Current alcohol use

A one standard deviation (SD) increase in neighborhood SES was associated with a reduction in the probability of current alcohol use for men and women (PR per 1 SD increase in neighborhood SES =0.96, 95% CI [0.96, 0.99], p=0.01 and 0.96, 95% CI [0.93,1.00], p=0.05, respectively) (Table 2). Individual-level income, however, modified the association between neighborhood SES and current alcohol use for women (Figure 1a), such that the association of neighborhood SES with current drinking was stronger in high-income women than in low-income women (p-value for interaction =0.01). Among high-income women, a 1 SD increase in neighborhood SES was associated with a 6% lower probability of current alcohol use where as in low income women a 1 SD increase was associated with a 1% lower probability. There was no association between alcohol outlet density and current drinking in men or women (Table 2).

3.2 Weekly alcohol use

Although no association between neighborhood SES and overall weekly alcohol use was observed, increasing neighborhood SES was associated with decreasing beer consumption for men and women (Ratio per SD increase in neighborhood SES= 0.84, 95% CI [0.78, 0.90], p<0.01 and 0.76, 95% CI [0.65, 0.88], p<0.01 in men and women respectively). The association of increasing neighborhood SES with decreasing weekly beer consumption was stronger in high versus low income men (p-value for interaction<0.01) (Figure 1b). While among men in the 10th income percentile a 1 SD increase in neighborhood SES was associated with a 12% decline in beer consumption, a 1 SD increase in SES was associated with a 16% decline in the highest income men.

For both men and women, an increase in the density of liquor stores per square mile was associated with a 7-11% increase in total weekly alcohol use (Ratio per 1 SD increase in liquor store density = 1.07, 95% CI [1.01, 1.05], p<0.05 and 1.11, 95% CI [1.01, 1.21], p<0.05 for men and women respectively) (Table 2). For men, this association was specific to beer consumption: each additional 4 liquor stores per square mile were associated with a 32% increase in weekly beer consumption for men (95% CI [1.17, 1.72], p<0.01) (Table 3). For women, the association between liquor store density and weekly alcohol use was specific to wine consumption; higher liquor store density was associated with a 16% greater in wine consumption per week for women (Rate per SD increase, 95% CI [1.03, 1.32], p<0.05). In addition, increases in bar density were associated with reductions in weekly liquor consumption for women (Rate per 1 SD increase =0.77, 95% CI [0.68,0.87], p<0.01), but not for men.

3.3 Heavy daily alcohol use

Neighborhood SES and alcohol outlet density were not associated with heavy daily alcohol use in men or women, and there was no evidence of heterogeneity.

4. Discussion

Our results indicate that changes in both alcohol outlet density and neighborhood socioeconomic status are associated with changes in alcohol use among older adults. Individuals who lived in neighborhoods with increasing densities of liquor stores increased their total weekly alcohol consumption over time. More specifically, higher densities of liquor stores were associated with increases in beer consumption for men and wine consumption for women. We also found that improvements neighborhood socioeconomic context were associated with decreases in the prevalence of current alcohol use and weekly beer consumption.

We found that increases in the density of liquor stores around a person's home were associated with increases in alcohol consumption. This is consistent with findings from much of the cross-sectional research (Connor, et al., 2011; Kavanagh et al., 2011; Pereira, Wood, Foster, & Haggar, 2013; Popova, Giesbrecht, Bekmuradov, & Patra, 2009). In the limited longitudinal research, results are mixed (H. L. Cooper, et al., 2013; Halonen, et al., 2013; Picone, et al., 2010), although few studies have separately examined the association between liquor store (off-site) density and bar (on-site) density and consumption. We found significant effects of liquor store density on weekly consumption, but no association between bar density and consumption. This may indicate that the availability of alcohol purchased off-site has a stronger influence on weekly consumption than the availability of places to drink alcohol on-site. More specifically, higher liquor store density was associated with increases in beer consumption for men and increases in wine consumption for women. These gender differences may reflect simple taste preferences, or they may support theories that men and women drink differently (M. L. Cooper, et al., 1992). We also found that increases in bar density were associated with decreases in weekly liquor consumption over time for women, which is counter to our hypotheses and the relationships between outlet density and other alcohol types. More research is necessary to understand gender differences in alcohol use as they relate to the neighborhood context.

Residents living in neighborhoods with increasing SES tended to experience reductions in the probability of being current alcohol users. These results support stress and coping theories, which hypothesize that people living in more socially and economically disadvantaged neighborhoods are more likely to drink alcohol to cope with the stressors associated with living in these neighborhoods (Conger, 1956; M. L. Cooper, et al., 1992). This may be particularly true for older adults, who may spend more time in their neighborhood than younger adults, resulting in greater exposure to stressors associated with neighborhood disadvantage. (A. V. Diez Roux, Borrell, Haan, Jackson, & Schultz, 2004). Many researchers have found a positive association between neighborhood SES and alcohol use, however, which is contrary to our findings (M. Cerdá, et al., 2010; S. Galea, et al., 2007). Additionally, in a recent cross-sectional paper using similar data, we found that higher neighborhood SES was associated with more alcohol use (Author et al., in press). One explanation for the discrepancy is that the estimate derived from cross-sectional research is confounded by individual-level factors that were more fully accounted for in the hybrid effect models by including both the between (mean) and within (deviation) terms in the model. We found that the coefficient for the mean neighborhood SES term included in the hybrid model for current alcohol use was consistent with that of the cross-sectional results (and in the opposite direction of our longitudinal coefficient derived from the deviation term), which suggests that estimates of mean effects or overall tendency may be different than the effect of change on change. Cross-sectional models of neighborhood SES and alcohol use may not adequately account for unmeasured or miss-specified confounding factors. By using hybrid effects models we were able to address between-person confounding factors, yielding different results than our cross-sectional analysis.

Among current drinkers, increasing neighborhood SES was associated with decreases in weekly beer consumption. While researchers have found that low neighborhood SES is associated with higher rates of heavy alcohol use/binge drinking (Fone, et al., 2013; K. Karriker-Jaffe, 2011; K. J. Karriker-Jaffe, et al., 2012; McKinney, Chartier, Caetano, & Harris, 2012), few have examined whether neighborhood SES is associated with weekly or total alcohol use, and only one study employed longitudinal data. Our research adds to the sparse evidence that neighborhood SES may influence rates of weekly alcohol consumption over time (M. Cerdá, et al., 2010; Matheson, et al., 2012). We did not find an association between neighborhood socioeconomic status and heavy daily alcohol use as other researchers have found (Fone, et al., 2013; K. Karriker-Jaffe, 2011; K. J. Karriker-Jaffe, et al., 2012; McKinney, et al., 2012). Most prior work, however, has been cross sectional. Only Cerdá et al (2010) employed a longitudinal analysis to examine the association of changes in neighborhood poverty and the odds of binge drinking. They found that increases in neighborhood poverty increased the odds of binging by over 80%, but their measure of binge drinking may have more accurately captured heavy/risky alcohol use than our measure of heavy daily use. The heavy daily use question in MESA asks participants to recall the highest number of drinks they consumed in a day during the previous 30 days, which may have been subject to recall bias and reporting error. Additionally, participants in the study by Cerdá et al. were from the Coronary Artery Risk Development in Young Adults (CARDIA) cohort, which is a much younger cohort (age 18-30 years at baseline) than our MESA sample. Heavier alcohol use tends to be higher among younger versus older adults (Karlamangla, et al., 2006).

A unique strength of our study was the separate examination of specific types of weekly alcohol consumption. We found an inverse relationship between neighborhood SES and rates of weekly beer consumption, but no association between neighborhood SES and weekly wine or liquor consumption. This may indicate that beer consumption is more strongly influenced by the neighborhood socioeconomic context that consumption of other types of alcohol. Beer is more affordable than most wine and liquor, so our results may simply reflect financial preferences. Jones-Webb and Kariker-Jaffee (2013) examined the association between neighborhood disadvantage and high alcohol content consumption and found that disadvantage was associated with the consumption of malt liquor and fortified wine but not high spirit volumes. Although additional research is necessary to better understand how neighborhood SES influences specific types of alcohol use, our results are in accordance with the limited evidence that the neighborhood context is not equally associated with all types of alcohol use (Jones-Webb & Karriker-Jaffe, 2013). Future research could explore economic and social explanations that may elucidate these differences.

Previous research on neighborhood context and changes in alcohol consumption has not investigated interactions between the neighborhood and individual-level factors, despite theoretical support that individual behavior is shaped by multiple levels of influence within a socio-ecological framework (Bronfenbrenner, 1979). We examined interactions between the neighborhood context and race/ethnicity and income in gender-stratified models and found that neighborhood context interacted with individual factors to jointly influence changes in alcohol use. We found some evidence that the relationship between neighborhood context and alcohol use varied by income. The association between neighborhood SES and the probability of alcohol use was stronger in high income than in low income women. We found similar results for beer consumption among women. This is consistent with theories of status inconsistency (Dressler, 1988), which would imply that higher SES women living in low SES neighborhoods may experience higher rates of distress and thus be at greater risk for alcohol use (N. Mulia & Karriker-Jaffe, 2012). It is also possible that higher income women simply have more financial means to purchase alcohol (possibly coupled with the greater availability of alcohol in low SES neighborhoods), which drives this interaction.

Several limitations should be considered when interpreting our results. First, our findings may not be generalizable. MESA participants are significantly healthier than the general population, as they had to be free of clinical CVD to be eligible for the study, and healthy people are more likely to consume alcohol than people with chronic illnesses (Naimi et al., 2005). MESA participants may also be less likely to drink heavily, as they are older and higher SES on average (Diane E Bild et al., 2005). Individuals who had more severe alcohol problems may have chosen not to enroll in the study, or they may be more likely to be lost to follow-up. If enrollment and attrition were related to their neighborhood environment, this may bias the results, although it would most likely result in an underestimate of the association between neighborhood context and alcohol use as we would expect participants in more disadvantaged neighborhoods to result in losses to follow-up.

While using a multi-site sample strengthens some aspects of generalizability of our findings, it also makes it more difficult to create buffers that are equally meaningful across sites. State wide differences in alcohol sale and zoning laws, as well as differences in the spatial distribution of the populations, may have resulted misspecification of the relevant spatial context in some areas. We used census tracts and a one-mile buffer around individuals' homes as measure of the neighborhood. People may purchase or drink alcohol outside of their neighborhoods, and this may be particularly true for higher SES individuals. In our older MESA sample, however, participants are more likely to be retired, and may stay closer to home than younger adults. To address the potential for a modifiable areal unit problem (MAUP) we conducted sensitivity analyses using ½ and 3 mile buffers and found some differences in the size of the coefficients for alcohol outlet density. The significance of the coefficients did not change for the majority of our models, although we recognize that MAUP is a limitation in this type of analysis. Although there may be some measurement error in our commercial database measure of alcohol outlet density (Hoehner & Schootman, 2010), using SIC codes to identify places of business is common and has been used in studies of alcohol availability (Katherine P Theall, Drury, & Shirtcliff, 2012; K.P. Theall et al., 2011). It is unlikely that this error is patterned such that it would create the observed associations.

Due to data availability, we were not able to separate bars from restaurants in our on-site outlet density measure, which restricts interpretation. Finally, given that an individual's SES influences the neighborhood in which they live, which may shape future SES, it is possible that time-dependent confounding biased our results. However, when older people move they typically do so to similar contexts (A. V. Diez Roux, et al., 2004). Moreover, in a previous study of associations of changes in neighborhood poverty and alcohol use (Magdalena Cerdá, 2010), researchers compared estimates from standard regression models to marginal structural models, and found that although confidence intervals were tighter in the marginal structural models, point estimates were very similar. In the presence of time-dependent confounding, our results most likely underestimated the effect of neighborhood on alcohol use.

Our study is one of few that assesses the relationship between alcohol outlet density, neighborhood SES, and alcohol use longitudinally, and is the first to include multiple types of alcohol use, which may be differently associated with the neighborhood context. Future work is necessary to understand why neighborhood context was differently associated with types of alcohol use. We also examined interactions between neighborhood context and individual factors on alcohol use, which has not yet been addressed longitudinally. One of the greatest strengths of our study is our use of hybrid effects models, which more fully control for confounders than mixed models. Although several researchers have examined these relationships longitudinally, few have had a ten-year follow-up period, with multiple measurement of neighborhood context and alcohol use during follow-up. We also examined multiple types of alcohol use, which is critical in trying to better understand how the neighborhood influences drinking patterns and in designing the most efficient and effective interventions to reduce harmful alcohol use. Finally, we were able to determine whether the association between neighborhood context and alcohol use varies based on social and demographic characteristics of the individual. Few researchers have considered this, and our study is the first to do so longitudinally.

Few researchers have examined longitudinal effects of alcohol availability on alcohol use, despite considerable evidence that increasing alcohol outlet density is associated with increases in alcohol-related harm like crime and violence and alcohol-related crashes (Campbell et al., 2009; Popova, et al., 2009). Although many researchers do not include measures of alcohol use in these studies, alcohol consumption is the hypothesized pathway between changes in outlet density and changes in alcohol-related harm (Campbell, et al., 2009). Our study was one of few to specifically examine the relationship between changes in alcohol outlet density and changes in consumption. Results from this study imply that implementing policies related to alcohol outlet zoning and land use policies for residential areas may be feasible ways to reduce residents' exposure to alcohol and regular alcohol consumption, as even more moderate consumption in older adults may result in alcohol related harms including auto crashes, falls, sleep problems and adverse drug interactions (Sorocco & Ferrell, 2006). Similarly, very little longitudinal research exists on the relation between neighborhood SES and alcohol use. We show that changes in neighborhood SES have implications for change in alcohol use. Directing prevention efforts to more disadvantaged neighborhoods would target older individuals who are most likely to be current alcohol users, ensuring that resources are not wasted. In summary, our results suggest that policies targeting neighborhoods may be important strategies for influencing population-level alcohol consumption.

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- Alcohol use was modeled as a function of neighborhood context
- Increases in neighborhood economic status resulted in decreasing alcohol use
- Increases in liquor stores resulted in increases in weekly drinking
- Relationships between neighborhood and drinking varied by individuals' income

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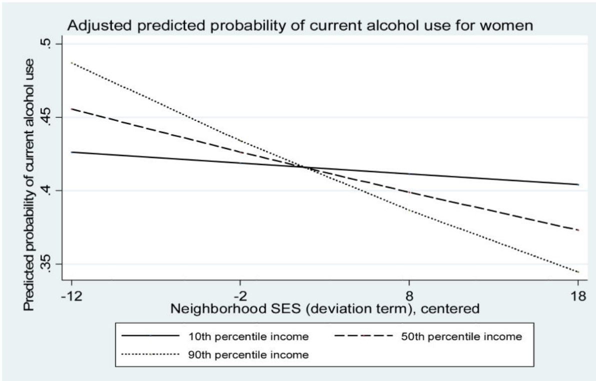

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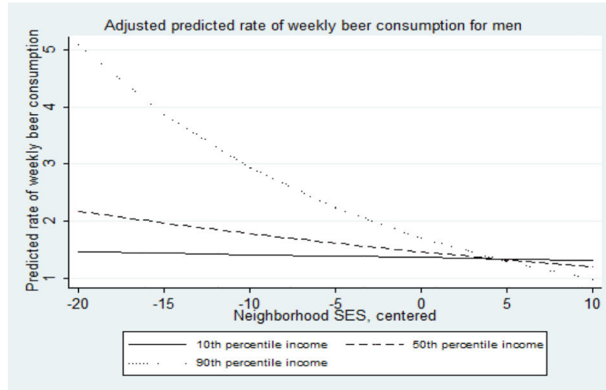

b

Figure 1.

Figure 1a represents the interaction of neighborhood SES (deviation term from hybrid effects model) and income on the probability of current alcohol use for women. Figure 1b represents the interaction of neighborhood SES and income on weekly beer consumption for men.

Table 1

Means (SD) and percentages for demographic factors, alcohol outcomes and neighborhood measures of the full analytical sample of MESA participants, Exams 1-5 (2002-2012)[a,b]

	Exam 1 N=6163	Exam 2 N=6030	Exam 3 N=5844	Exam 4 N=5589	Exam 5 N=4513
Years since baseline exam	0 (0.0)	1.6 (0.3)	3.2 (0.3)	4.8 (0.3)	9.5 (0.5)
Age	61.9 (10.1)	63.6 (10.1)	64.9 (10.0)	66.4 (9.9)	70.0 (9.5)
Male (%)	47.5	47.5	47.2	47.1	46.8
Race/ethnicity (%)					
White	39.4	39.5	40.0	40.5	41.0
Black	27.3	27.3	27.0	26.9	26.4
Hispanic	21.6	21.4	21.1	21.0	20.9
Chinese	11.7	11.8	11.8	11.5	11.7
Annual gross family income ($10,000)	5.0 (3.4)	4.9 (3.4)	5.0 (3.5)	5.1 (3.5)	5.4 (3.6)
Education	13.2 (4.0)	13.2 (4.0)	13.3 (3.9)	13.3 (3.9)	13.5 (3.8)
Employed (%)	48.2	45.9	44.4	41.9	36.3
Married/living w/ partner (%)	62.0	61.8	62.1	62.6	59.3
Drinking status (% drink)	56.0	51.2	49.4	44.6	42.7
Drinks of all alcohol/week	-	2.9 (6.2)	3.0 (6.9)	2.8 (6.4)	2.9 (7.0)
Highest drinks/day	1.5 (2.3)	1.4 (2.3)	1.4 (2.7)	-	-
NH SES	0.1 (6.3)	0.1 (6.3)	0.8 (5.8)	1.9 (4.9)	1.1 (4.6)
Liquor outlet density	2.9 (3.7)	2.9 (3.9)	2.9 (4.1)	3.1 (4.6)	2.7 (4.1)
Drinking place density	4.0 (7.9)	4.0 (7.9)	4.0 (8.1)	4.4 (9.0)	4.8 (8.8)

[a]Sex, race and education are not time-varying

[b]Full analytical sample refers to the maximum available data at each exam

Table 2

Associations of a 1 SD change in neighborhood context with changes in current alcohol use, average number of drinks consumed per week, and number of drinks consumed on heaviest drinking day for men and women: MESA, 2002-2012[a,b]

	Probability ratios of current alcohol use	Ratios of number of drinks/ week annually	Ratios of highest number of drinks/day annually
		Men	
Neighborhood SES	**0.96 (0.96,0.99)**[d]	0.96 (0.90,1.02)	0.98 (0.94,1.03)
Liquor store density[c]	1.01 (0.98,1.04)	**1.07 (1.01,1.05)**	0.99 (0.94,1.04)
Bar density[c]	0.98 (0.96,1.00)	1.00 (0.95,1.05)	0.99 (0.95,1.02)
Total alcohol outlet density[c]	0.99 (0.97,1.02)	1.01 (0.96,1.06)	0.99 (0.95,1.03)
		Women	
Neighborhood SES[b]	0.96 (0.93,1.00)[d],[e]	1.01 (0.93,1.08)	1.01 (0.95,1.07)
Liquor store density[c]	1.02 (0.99,1.06)	**1.11 (1.01,1.21)**	1.05 (0.98,1.03)
Bar density	0.99 (0.96,1.01)	1.02 (0.96,1.09)	1.00 (0.96,1.05)
Total alcohol outlet density	0.99 (0.97,1.02)	1.04 (0.98,1.11)	1.01 (0.97,1.06)

Bolded values are significant at $p<0.05$

[a] Models include years since baseline exam, age, gender, race/ethnicity, marital status, income, education and employment status, and significant interactions between time-invariant predictors and time.

[b] Ratios for continuous neighborhood predictors correspond to a 1 SD change in neighborhood measure.

[c] Model includes neighborhood level SES.

[d] Estimate corresponds to the within-person deviation term (mean term not included in table).

[e] p-value=0.05

Table 3

Associations of a 1 SD change in neighborhood characteristics with changes in average number of drinks of beer, wine and liquor consumed per week for men and women: MESA, 2002-2012.[a,b]

	Ratios of drinks Beer	Ratios of drinks Wine	Ratios of drinks Liquor
		Men	
Neighborhood SES	**0.84 (0.78,0.90)**	1.05 (0.95,1.17)	0.98 (0.88,1.08)
Liquor store density[c]	**1.32 (1.13,1.53)** [d]	1.09 (0.99,1.21)	1.05 (0.97,1.14)
Bar density[c]	0.90 (0.82,1.00)	1.00 (0.94,1.07)	1.03 (0.95,1.12)
Total alcohol outlet density[c]	1.12 (0.93,1.34)[d]	1.02 (0.95,1.10)	1.04 (0.96,1.25)
		Women	
Neighborhood SES	**0.76 (0.65,0.88)**	0.92 (0.82,1.04)[d]	1.07 (0.98,1.17)
Liquor store density[c]	1.37 (0.96,1.96)[d]	**1.16 (1.03,1.32)**	0.88 (0.72,1.08)
Bar density [c]	1.02 (0.83,1.24)[d]	1.03 (0.96,1.13)	**0.77 (0.68,0.87)**
Total alcohol outlet density[c]	1.14 (0.89,1.45)[d]	1.06 (0.97,1.16)	**0.78 (0.68,0.89)**

Bolded values are significant at p<0.05

[a]Models include years since baseline exam, age, gender, race/ethnicity, marital status, income, education and employment status, and significant interactions between time-invariant predictors and time.

[b]Ratios for continuous neighborhood predictors correspond to a 1 SD change in neighborhood measure.

[c]Model includes neighborhood level SES.

[d]Estimate corresponds to the within-person deviation term (mean term not included in table).