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Selection and socialization influences on adolescent alcohol use: The individual and joint contexts of neighborhood disadvantage and population density.

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Abstract

Background: Neighborhood disadvantage (ND) and population density (PD) are two community characteristics contextualizing friends' influence on adolescent alcohol use. However, these community characteristics are rarely examined for potential joint contributions, although it is possible that the way friends are selected or influence alcohol use are shaped by both ND and PD. In addition, prior studies examining ND or PD contexts on friend influence rarely discern between socialization and selection.

Objectives: The current study examined how selection and socialization influences on adolescent alcohol use are shaped by unique and joint contexts of ND and PD.

Methods: Adolescents from Waves I and II of the National Longitudinal Study of Adolescent and Adult Health (Add Health) were included in three models assessing friends' socialization of alcohol use initiation and binge drinking, and selection of drinking friends. ND and PD were tested for mediation and moderation individually and jointly.

Results: Results indicated that socialization of drinking initiation was stronger in high ND contexts, and that continued binge drinking was stronger in low ND contexts. PD indirectly influenced socialization of initiation and binge drinking maintenance via a negative association with number of drinking friends. PD and ND jointly influenced the association between initial binge drinking and next-year selection of drinking friends, such that selection was stronger within areas related to lower levels of drinking friends.

Conclusions/Importance: Current results indicate that PD and ND shape friends' influence on alcohol use in unique ways. These must be accounted for to better understand bidirectional effects of friend influence.

Adolescents who drink tend to have more drinking friends. The two main mechanisms underlying the relation between adolescent alcohol use and drinking friends are socialization, in which friends encourage and reinforce alcohol use, and selection, in which drinking plays a role in who adolescents select as friends (Breechwald & Prinstein, 2011; Leung, Tombourou & Hemphill, 2011). Selecting friends and endorsing or adopting friend

norms and behaviors are important parts of developing an identity within adolescence, which increases vulnerability to peer drinking influences (e.g., Balsa, Homer, French & Norton, 2011; Burk van der Vorst, Kerr & Stattin, 2012).

Alcohol use becomes an important criterion for selecting friends in adolescence (Huang, Soto, Fujimoto & Valente, 2014). It is an attractive behavior associated with higher social status (Allen, Porter, McFarland, Marsh & McElhaney, 2005), and is instrumental for social statuses in larger social networks such as schools (Deutsch, Steinley, Sher & Slutske, 2017; Moody Brynildsen, Osgood, Feinberg & Gest, 2011). Adolescent drinkers are highly likely to select friends with similar drinking behaviors, compared to non-drinkers, who have a slight preference for fellow non-drinkers, but will also select drinking friends (Osgood, Ragan, Wallace, Gest, Feinberg & Moody, 2013).

Due to the preference of including drinking friends in one's friendship group, and the attractiveness of drinking, adolescents are incentivized to adopt high-status behaviors such as drinking as a way to develop a positive sense of social self (e.g., someone who is well-liked or popular; Mayeux Sandstrom & Cillissen 2008). Friends and peers are also primary drinking contexts in adolescence; drinking in adolescence is most often a social activity (Goncy & Mrug, 2013; Kuntsche Knibbe, Gmel & Engels, 2006). Friends' socialization effects are related to initiation, maintenance and escalation of individual drinking (Ennett et al., 2006; Ennett et al., 2008) as adolescents are rewarded for adherence to group norms. Selection and socialization mechanisms of friend or peer influence have been indicated as uniquely influential (Simons-Morton & Chen, 2006; Steglich Snijders & Pearson, 2010) and bi-directional over adolescence (Curran, Stice & Chassin, 1997). These results illustrate a potential positive feedback loop, in which individuals select friends who drink. Such friends influence individual drinking behavior, and individual behavior promotes selection of more drinking friends.

Geographical Contexts

Some research focuses on broader contexts that shape and define the influence of drinking friends, such as neighborhoods (e.g., Chuang, Ennett, Bauman, & Foshee 2009; Zimmerman & Farrell, 2016). Real-world social network formation and development of friendships are constrained by social and spatial environment (Back, Schmukle, & Egloff, 2008; Huckfeldt, 1983; Schaefer, 2012). Neighborhoods have a clear hand in shaping: a) availability of specific peers, b) the opportunities to select these peers as friends, and c) the ways in which friends socialize with each other (e.g., proximity to friends, resources and contexts that facilitate socializing). A commonly examined context is neighborhood disadvantage (ND), which typically focuses on structural neighborhood characteristics such as area-level SES/poverty, lack of resources and/or lack of opportunities.

Although there is mixed evidence for a direct effect of ND on alcohol use (Bryden, Roberts, Petticrew & McKee, 2013; Karriker-Jaffe, 2011), ND appears to have an indirect effect via friend use. ND relates to availability of access to substances (e.g., alcohol outlets, substance-using peers; Duncan, Duncan & Stryker, 2002), and affiliation with substance-using friends (Chuang, Ennett, Bauman & Foshee, 2005). This indirect effect could potentially be

explained by more proximal, social-level neighborhood characteristics (social disorganization, collective efficacy, Sampson & Groves, 1989; Sampson, Morenoff & Gannon-Rowley, 2002), associated with both ND and neighborhood alcohol use. However indirect effects between ND and individual use via friends' alcohol use hold even when controlling for social components of community disadvantage (e.g., Brody, Ge, Conger, Gibbons, Murry, Gerrard & Simmons, 2001; Trucco, Colder, Wieczorek, Lengua & Hawk, 2014). Another possibility is that ND moderates the association between friend and personal alcohol use. Rather than increasing or decreasing opportunity for friend effects, ND itself may moderate the strength of friend effects. Few studies have examined this possibility, however results are inconsistent (Jackson, Denny & Ameratunga, 2014; Snedecker, Herting & Walton, 2009; Tucker, Pollard, de la Haye, Kennedy & Green, 2013).

Population density (PD) is also an important, but less studied neighborhood context shaping peer or friend effects on adolescent alcohol use. Highly rural areas also face substantial poverty-affiliated consequences (Dew, Elifson & Dozier, 2007). There is evidence that rural adolescents consume more alcohol/engage in riskier drinking behaviors compared to their urban or suburban peers (Atav & Spencer, 2002; Coomber, Tombourou, Miller, Staiger, Hemphill & Catalano, 2011; Hanson, Novilla, Barnes, Eggett, McKell, Reichman & Havens, 2009). Rural contexts provide higher risk for substance use (Gale, Lenardson, Lambert & Hartley, 2012; Spoth, Goldberg, Nepl, Trudeau & Ramissetty-Mikler, 2001). PD may play an indirect role similar to ND (such that lower PD relates to higher availability of substance-using peers to select as friends). Although PD is rarely examined as an indirect effect, studies have examined PD as a moderator of friend use on individual use, indicating that friend influence is stronger for urban compared to rural adolescents (Clark, Nguen & Belgrave, 2011; Wilson & Donnermyer, 2006). Urban adolescents may have easier access to both drinking peers and spaces to engage in drinking and socialization. Closer proximity to risky spaces (e.g., recreation areas) relates to higher levels of substance use (e.g., Mennis, & Mason, 2011). Adolescents in lower PD areas can have higher access to alcohol through their parents (Chan et al., 2016). Although proportions of drinking peers may be higher in low PD areas, which could indicate higher rates of drinking friends, the constraint of lower proximity to peers within these areas and higher familial influence may decrease the strength of friend influence on individual alcohol use.

PD and ND are rarely examined simultaneously as contexts of adolescent alcohol use or as contexts that shape peer effects on alcohol use. Most studies examining the impact of ND on adolescent alcohol use focus exclusively on urban areas (Bryden et al., 2013). For studies that include multiple neighborhoods with different PD, these characteristics are typically ignored even as control variables (e.g., Arthur, Hawkins, Pollard, Catalano & Baglioni, 2002; Brody et al., 2001; Buu, Wang, Wang, Puttler, Fitzgerald & Zucker, 2011). Overall, research indicates that PD and ND relate to components of the peer influence process on alcohol use in separate ways. Individual adolescent alcohol use differs across PD areas (Coomber et al., 2011), affiliation with alcohol-using peers differs across ND areas (Trucco et al., 2014), and PD and ND relate to friend influences on alcohol use in separate ways (moderation of direct effects and indirect mediated effects; Clark et al., 2011, Brody et al., 2001). However, due to barriers placed on proximity to friends in lower PD areas, which would typically require more income to overcome (e.g., personal transportation accessibility

for larger distances between friends, which are related to higher income (Anderson & Hughes, 2009)), it is unlikely that ND effects operate similarly across all areas of PD, and vice versa. However, few studies examine the joint effects of ND and PD on peer/friend influence. To our knowledge, only one study has examined peer effects within the joint contexts of ND and PD. Using latent-class profiles, Cheung et al., (2009) documented that socialization influences were stronger in urban and suburban areas, regardless of area-level socioeconomic status, indicating an interaction between PD and peer influence. However, this study used broad categorical designations of PD and ND and did not distinguish between socialization or selection (i.e., a cross-sectional relationship between drinking friends and personal drinking), and only examined early adolescents (ages 12–14).

Most studies examining ND and/or PD as a contextual influence on peer effects fail to account for nuances between either selection and socialization, or socialization of initiation versus maintenance of alcohol use. A main argument for the importance of high ND on peer influence is the increase in number of drinking peers or friends (Brody et al., 2001; Chuang et al., 2005), even if ND appears to have little influence on adolescent alcohol use itself (Bryden et al., 2013). Therefore, although adolescents in higher ND areas may have more opportunity to socialize with drinking friends, it is unknown if ND plays a role in how individual alcohol use relates to the selection of these friends. Similarly, many studies on ND/PD contexts of peer socialization do not discern between initiation and maintenance behavior (e.g., Clark et al., 2011; Duncan et al., 2002) or only examine either initiation or maintenance (e.g., initiation, Trucco et al., 2014; Tucker et al., 2013). Given the bidirectional relationship between socialization and selection (Curran et al., 1997), it is unknown if PD and ND play consistent roles over this longitudinal process.

Current Study

The current study examined how ND and PD may be individual and joint contexts that shape selection and socialization influences on adolescent alcohol use. Specifically, we examined four research questions. First, we examined if ND and PD are individual predictors of both socialization and selection models of adolescent use, as expressed through mediation. That is, do ND and PD have indirect effects on next year individual/friend drinking outcomes by “setting the stage” through direct influence on initial effects? Second, we examined if ND and PD can impact the strength of socialization and selection effects as moderators of initial levels of friend/individual use on next-year friend/individual use. In other words, do ND and PD have individual influence on the strength of selection or socialization effects? We also examined if ND and PD had joint effects, as expressed through a General Joint Analysis model (Fairchild & MacKinnon, 2009) in which moderation and mediation effects can be examined simultaneously. There were two main ways we expected this could occur: a moderated mediation model, or a three-way direct moderation model. A moderated mediation model would indicate that the indirect effect of one neighborhood characteristic would only exist at certain levels of a second neighborhood characteristic. The three-way direct model would indicate that rather than an indirect effect, the two neighborhood characteristics work together to influence the peer effect on the outcome. Finally, we examined if PD and ND effects were similar for socialization of alcohol initiation, maintenance of binge drinking, and selection of drinking friends.

Based on prior research, we hypothesized that drinking friends would mediate a positive association between ND and drinking behavior (Brody et al., 2001, Trucco et al., 2014). We also expected to find interactions between PD and drinking friends on drinking behavior, such that socialization effects would be stronger in high PD areas (Clark et al., 2011). As prior work indicates ND effects drinking behavior via mediation (by drinking friends) and PD effects drinking behavior by moderation (on the effect of drinking friends), we expected that the most plausible ND $\times$ PD joint interaction would be a PD moderated, ND mediated model, in which indirect effects of ND are higher in high PD areas. Given less emphasis on selection effects, we were unsure about how PD and ND could contextualize selection of drinking friends.

Method

Participants

Participants were from Waves I (WI) and II (WII) from the National Longitudinal Study of Adolescent and Adult Health (Add Health), a longitudinal study of a nationally representative sample of adolescents in grades 7–12 in the United States first surveyed during the 1994–95 school year, and then followed up one year later. The 80 high schools selected are representative of US schools with respect to country region, urbanicity, size, type, and ethnicity. Only those who completed both waves were included, for a total sample of $N = 13,420$. The sample was 49% male and 51% female, 54% European American, 21% African American, 9% Latino/a, 7% Asian American/Pacific Islander, 2% American Indian/Alaska Native, and 8% biracial. The average age was 15.31 ($SD = 1.60$).

Measures

Binge Drinking Initiation.—Individuals who reported no onset of alcohol in WI were asked in Wave II if they had ever 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 reported “yes” were coded as initiating at WII (1), while those who reported “no” were coded as abstaining at WII (0).

Binge Drinking Frequency.—Drinking frequency was assessed in WI and WII with the question “over the past 12 months, on how many days did you drink five or more drinks in a row?”. The initial scale was reverse-scored, such that higher scores reflected higher frequency of drinking, on a scale of 0 (never) to 6 (every day/almost every day). This variable was utilized as a continuous variable,

Number of Drinking Friends.—Number of drinking friends was assessed in WI and WII with the question “Of your three best friends, how many drink alcohol at least once a month”. Scores ranged from 0 (no friends drink once a month) to 3 (all friends drink once a month). This variable was coded as a count variable.

Neighborhood disadvantage (ND).—ND was a composite measure that assessed block-level characteristics derived from the 1990 Census that were applied to participants’ geocodes¹. The measure included block-level proportions of households lacking basic

plumbing or a kitchen, unemployment, proportion of those without a college or high school degree, proportion of individuals and families living below poverty level, and proportion of single parent-homes. Higher scores indicated higher levels of disadvantage. Similar measures of ND within the Add Health data (with tract, rather than block level indicators) have previously been used (Slutske, Deutsch & Piasecki, 2016). All variables were highly related, with a Cronbach's alpha of $\alpha = 0.80$. The score was then truncated at 0.37 (98.77% of the sample reporting 0.37 or lower).

Population density (PD).—PD was recorded as the block group-level number of people (per thousand) per square kilometer for the 1990 Census. This parameter was initially skewed (skewness = 6.47), with 51% of the sample reporting less than 1 person (per thousand) per square kilometer within their tract. The density variable was first rounded to the nearest 0.01. We then recoded all scores higher than 18 (1% of the sample, with scores ranging from 18 to 87.52). Scores ranged on a continuous scale from 0 to 18 (e.g., 0 to 18 people per thousand, per square kilometer).

Demographics.—Age, gender, and race/ethnicity were added as control variables. Gender was a binary variable, in which boys were the reference group. Race was a categorical dummy-coded variable in which European American status was the reference group, compared to African American, Latino/a and “other race” (e.g., Asian American/Pacific Island, American Indian/Alaska Native, and biracial).

Analytic Plan

There were three models, two examining socialization outcomes (initiation of drinking and binge drinking frequency predicted by drinking friends), and one examining selection (number of drinking friends predicted by binge drinking frequency). The initiation model included only individuals who reported abstaining at WI ($n = 6087$), and the binge drinking frequency and friend selection models included only individuals who reported having initiated alcohol use by WI ($n = 7333$). The TYPE = COMPLEX function in Mplus 8.0 was used to ensure proper handling of clustered data for all models, and longitudinal survey weights and stratification of region codes were included to ensure proper standard errors. Missing data was handled by using robust maximum likelihood (MLR) estimators for linear and count data. The binge drinking socialization model was estimated using a linear regression, and the selection model used a Poisson regression for count data.²

The models required different approaches to estimating mediation effects. Estimating a non-normal outcome or mediator (e.g., count data) using traditional mediation approaches often leads to biased results (e.g., Iacobucci, 2012; MacKinnon & Cox, 2012). Mplus allows for treating non-normal mediators and outcomes as latent response variables (when a mediator

¹Block groups are collections of blocks, which are statistical areas bounded by visible (e.g., streets, roads, rivers) and nonvisible (e.g., property lines, district lines) boundaries (US Census, 2017). They are the smallest unit for published sample data, and are not always analogous to size or population of a region. For example, while a city block may be a block of a city bounded on all sides by streets, blocks in suburban or rural areas are larger and more irregular - in remote areas, census blocks may be hundreds of square miles. For the 1990 Census, block groups had on average 1,100 people.

²Model fit for Poisson regression was compared to zero-inflated and negative binomial models, and was selected as the best fitting model. Comparisons/results available upon request.

is non-normal, it is treated as a latent outcome and observed predictor). This approach allows for counterfactually based causal definitions of effects (Muthen & Asparouhov, 2015; Nguyen, Vargas, Koning & Stuart, 2016). A counterfactual causal model compares the effect of a treatment or level of a variable that an individual was exposed to (e.g., one drinking friend), to the other levels or treatments an individual was not exposed to (e.g., zero, two, or three friends). The effect is considered causal as the effect of a specific treatment or level of variable is compared against all other possibilities (Hofler, 2005). The true natural indirect effect (TNIE) represents the effect of the predictor on the outcome that is explained by the mediator. The pure natural direct effect (PNDE) reports the effect of the predictor on the outcome not explained by the mediator. Together, these two are the sum total effect. Counterfactual approaches were used for the Poisson (selection; count outcome) model, and the Probit (initiation socialization; binary outcome) model. Causal effect formulas for TNIE and PNIE are documented in Muthen, 2011 and Muthen & Asparouhov, 2015. Mediation estimates for the linear regression (drinking socialization) were calculated using the traditional approach, as there is no current way to treat count mediators as continuous latent response variables in Mplus. Treating count mediators as continuous variables is discussed in Muthen 2011.

Figure 1A displays the three steps used for both models. All steps build toward a General Joint Analysis model as described in MacKinnon (2008) and Fairchild & MacKinnon (2009). Step 1 is represented by solid lines, Step 2 is represented by long dash lines, and Step 3 is represented by short dash lines. First, a mediation-only model was estimated. This model examined if ND and PD directly associated with initial levels of friends/individual drinking, and indirectly predicted next-year levels of friends/individual drinking. The second model included separate interactions between ND and PD and the mediator-dependent variable path (see Stride, Gardner, Catley & Thomas, 2015, p 732 for a discussion of the syntax for an independent variable-moderated mediation model). In other words, we tested to see if after accounting for direct and indirect effects of ND and PD on friends drinking/individual drinking, that ND or PD could also influence socialization or selection peer influence effects. The third model included two $ND \times PD$ interactions on both the mediator and the outcome, and a three-way interaction between the mediator and the mediated variables to test full moderated mediation models. This would allow for simultaneous testing of a moderated mediation model, as well as a three-way direct moderation model. As discussed in Fairchild & MacKinnon (2009), a significant mediated model (i.e., a pathway between X and Y mediated by M) can be moderated by a fourth variable that is regressed onto both the mediator and the outcome (Z is an additional predictor for M and Y). For a significant moderated mediation model, there must be at least two interactions present: An interaction between X and Z predicting the mediator, and an interaction between M and Z predicting Y. For example (Figure 1B), to test if a significant indirect ND effect on drinking behavior varies across levels of PD, two significant interactions are required. First, there must be a significant interaction between ND and PD on the mediator (drinking friends). Second, there must be a significant interaction between PD and the mediator on the outcome (drinking behavior). Finally, a three way $ND \times PD \times$ mediator interaction would indicate if PD and ND jointly influence the direct peer effect pathway. Although this is not a required step for the General Joint Analysis model, we included this analysis to test if the lower-order

two-way interactions provide a complete interpretation of the model effects, and to compare against a moderated mediation model as the most plausible way that ND and PD jointly influence socialization and selection behavior. Finally, given the large number of analyses, we examined alpha inflation of all three models by a conservative Bonferroni correction; there were 15 total tests for the initiation model, and 16 total tests for the socialization and selection models (each). For all models, the correction we used was $p < .003$.

Results

Table 1 reports the correlations between all variables for the abstainer and non-abstainer group, for adolescents of all ages. As expected, binge drinking frequency and drinking friends were positively associated to each other at each wave. Both ND and PD were negatively associated to drinking friends and binge drinking frequency for non-abstainers, and ND positively associated with drinking friends at WI for abstainers, while negatively associated with WII drinking friends (when some WI abstainers initiated alcohol).

Alcohol Use Initiation Socialization

As seen in Table 2, drinking friends had a positive relationship with the odds of next-year alcohol use initiation, such that for every additional drinking friend at WI, odds of initiating alcohol use next year increased by 122%. ND had a significant direct effect on alcohol initiation as well; odds of initiating alcohol use decreased as ND increased. There was a significant indirect effect of ND (TNIE for binary Y [initiation] variable = 1.62 $p < 0.05$, 95% CI (1.20 – 1.98)) on the odds of next-year initiation. Taken together, although the relationship between ND and drinking initiation is negative, adolescents in higher ND areas will be more likely to have drinking friends, who in turn, will have a positive effect on odds of drinking initiation).

PD had no direct relationship with the odds of initiation, and this appeared to be due to a full (minor) mediation effect via the negative association between PD and drinking friends (TNIE for binary Y [initiation] variable = 0.99 $p < 0.05$, 95% CI (0.98 – 1.00)). PD had a negative effect on number of drinking friends, such that for each unit decrease in PD, the number of drinking friends increased by .02; thus, there was a negative indirect effect for PD on drinking initiation through drinking friends.

There was one moderation effect. ND moderated the pathway between drinking friends and alcohol initiation (OR = 2.97, $p > .05$, 95% CI = 1.76 – 4.00)). As seen in Figure 2, having no drinking friends was related to lower odds of initiating drinking for adolescents living in high ND areas, compared to low ND areas. Conversely, having 3 drinking friends was related to higher odds of initiating drinking for adolescents living in high ND compared to low ND areas. In addition, the positive interaction between ND and PD on number of drinking friends indicated that the mediated pathway, (a negative indirect effect of PD on initiation, via a negative PD – drinking friends association, and a positive drinking friends – initiation effect) differed over ND, such that the indirect effect was significant in low ND, but not high ND areas. Supplemental Table 1 demonstrates this effect. As seen in Supplementary Table 1, under low ND areas, the 95% confidence intervals for TNIE odds ratios do not cross 1, indicating significance. Under higher ND areas, the 95% confidence

intervals for TNIE cross 1 indicating non-significance. Finally, there was no three-way interaction, indicating that PD did not moderate the mediated relationship between ND and alcohol initiation.

Binge Drinking Frequency Socialization

As seen in Table 3, both the number of drinking friends and initial drinking frequency positively related to next-year binge drinking frequency. For every additional drinking friend, the frequency of binge drinking increased by .21. There was a significant, negative direct effect of PD on drinking frequency, however this was partially mediated by initial number of drinking friends ($ind = -0.006$, $p < .001$ 95% CI $(-0.01 - -0.003)$). Adolescents living in lower PD areas had more initial drinking friends; more initial drinking friends related to an increase in binge drinking frequency one year later.

There was no direct effect of ND on binge drinking frequency, nor was there a mediated effect via drinking friends ($ind = 0.02$, $p > .05$, (95% CI $= -0.63 - 0.10$)). However ND significantly moderated the effect of drinking friends on next year binge drinking frequency ($b = -0.739$ $p = .04$, 95% CI $= (-1.32 - -0.16)$). As seen in Figure 3, number of drinking friends appeared to have a larger impact in predicting frequency of binge drinking in low ND compared to high ND areas; individuals in higher ND areas were more similar in their binge drinking frequency regardless of the number of drinking friends compared to those in low ND areas. However, unlike drinking initiation, ND did not moderate the mediated PD pathway, as indicated by the non-significant interaction between PD and ND on initial drinking friends. In addition, there was no three-way interaction between ND, PD, and initial drinking friends, indicating that ND and PD uniquely, but not jointly, affected the socialization effect of drinking friends on binge drinking frequency.

Number of Drinking Friends Selection

As seen in Table 4 both initial binge drinking frequency and initial number of drinking friends positively predicted next-year number of drinking friends. For every unit increase in binge drinking frequency, the incidence rate ratio of number of drinking friends increased by 104%. ND had a significant negative direct, but not indirect effect (TNIE = 0.005, $p > .05$ (95% CI $= -0.01 - 0.02$)) on number of drinking friends. PD had a significant, but small indirect relationship with number of drinking friends, as mediated by initial levels of binge drinking (TNIE = -0.001 , $p < .05$ (95% CI $= -0.002 - 0$)). Neither PD nor ND individually moderated the impact of frequency on drinking on number of drinking friends. The indirect effect of PD was not moderated by ND, given the lack of a significant interaction between ND and PD on initial drinking frequency. However, there was a three-way interaction between PD, ND, and binge drinking frequency, indicating that PD and ND jointly moderated the selection effect of initial drinking on drinking friends. As seen in Figure 4, the selection effect of drinking on drinking friends overall was stronger in lower, compared to higher ND areas. However, this interaction effect was stronger for higher PD areas. The strongest effect of selection appeared to be in low ND, high PD areas.

Discussion

The current study examined ways in which ND and PD independently and jointly influence adolescent alcohol selection and socialization effects. As we suspected, ND and PD had unique and joint effects on selection or socialization. In addition, the way that ND or PD influenced friend effects differed across all three outcomes. Although we expected that, for socialization, ND would have a positive indirect effect, and PD would have a positive moderating effect, this hypothesis was overall, not supported, except for a positive indirect effect of ND on alcohol initiation. However, when examining PD and ND jointly for the initiation model, we found that ND moderated the indirect negative influence of PD on alcohol initiation, such that this indirect negative effect was significant in lower ND areas (i.e., the opposite of what was hypothesized).

When taken together, the three models demonstrate the ways in which ND and PD shape reciprocal selection and socialization influences within an adolescents' trajectory of drinking. Although we only have two waves of data, we will present a cohesive picture of these results by framing the discussion within a longitudinal bidirectional pathway of drinking and peer effects.

Socialization influences on alcohol initiation.

Adolescents in low ND areas were more likely to initiate alcohol use. However, this effect was partially mediated by a positive association between ND and number of drinking friends, a finding supported by previous literature (Brody et al., 2002, Snedeker et al., 2009). The negative association between drinking and ND is typically explained as a function of availability, opportunity, and affordability. For example, parent drinking is higher in high SES neighborhoods (Chuang, et al., 2005). Alcohol use frequency (but not binge/misuse) relates to higher SES (Casswell, Pledger, & Hooper, 2003; Cerda, Johnson-Lawrence, & Galea, 2011; Fone et al., 2013). Thus, alcohol may be more readily available within the household. Additionally, although higher ND areas have higher rates of alcohol outlets (Pollack, Cubbin, Ahn & Winkleby, 2005), alcohol outlet density is not able to explain a clear association between lower ND and higher alcohol use frequency (Slutske, Deutsch & Piasecki, 2016). Adolescents from higher-income families (who live in lower ND areas), are more likely to have the personal resources to obtain alcohol regardless of proximity to alcohol outlets. Both the mediation effect, and the significant interaction between direct effects of ND and number of drinking friends, indicate that friend use may become a more important influence for adolescents in higher ND areas. Having friends who drink can mitigate or eliminate the initial barriers of alcohol initiation in higher ND areas (mediation); as such, these friends are particularly important for obtaining alcohol and initiating use in high ND areas (moderation).

PD also had an indirect negative effect on drinking initiation via a negative association with number of drinking friends. Therefore, adolescent abstainers in less populated areas had a higher number of drinking friends, and in turn, a higher number of drinking friends increased odds of initiation. It is possible that the negative association is an artifact of a higher proportion of adolescent drinking frequency within lower PD areas (see Table 1; Atav & Spencer, 2002; Coomber, et al. 2011; Hanson et al, 2009). Within rural areas, if a large

number of adolescents are already drinking, abstainers will have a lower opportunity to select friends who are fellow abstainers.

Finally, our hypothesis that joint effects of ND and PD would best be manifested via a moderated mediation model was supported. However, we expected that PD would moderate an ND mediation model, such that the positive indirect effect of ND would be stronger in higher PD areas. Opposite to what we hypothesized, ND moderated the indirect effect of PD, such that the indirect effect was slightly stronger in lower ND areas. Similar to the interaction between ND $\times$ drinking friends, this may be due in part to easier alcohol access through parents or monetary resources. However, given that proximity to other friends decreases in more rural areas, more advantaged areas are also more likely to have more access to transportation (e.g., cars). In rural areas where distance between friends can create potential barriers to socialization, adolescents in more advantaged communities will have the means to overcome these barriers, spending more time with friends, and increasing the effect of socialization. Taken together, adolescents in low PD and high ND areas have the highest access to drinking peers. Drinking peers serve as way to overcome initial alcohol access barriers in high ND areas to facilitate initiation, although high ND may increase difficulties to access of peers in low PD areas.

Selection influences for drinkers.

ND and PD played a joint, direct role for the way in which alcohol use influences selection of friends for non-abstainers via a three-way interaction, contrary to our initial hypothesis that joint ND – PD effects would be demonstrated through a moderated mediation model. In contrast to the initiation model, selection effects were the strongest in low ND, high PD areas. Selection effects are the strongest in areas that are considered to have the lowest access to drinking peers (Chuang et al., 2005; Clark et al., 2011). For non-abstaining adolescents, finding drinking friends may be more important when there is lower availability of drinking peers, particularly when adolescents have personal access to alcohol in lower ND areas. As alcohol use is seen as both a high-status and social activity (Kuntshe et al., 2006; Osgood et al., 2013), “drinking buddies” may become particularly important for those who have access to alcohol, but not easy access to other drinking peers.

PD also had an additional background role as an indirect effect on number of drinking friends. Frequency of binge drinking mediated the negative relation between PD and number of drinking friends. Similar to the socialization effect on initiation, there were higher rates of drinking and drinking friends in rural areas, however, these effects were similar for adolescents within high and low ND areas. Taken together, selection effects appear to be stronger in areas with lower levels of drinking friends (possibly making drinking as a selection criteria more important for those with higher rates of drinking); however rurality plays a consistent, continual role as a context that facilitates higher rates of both personal drinking behavior and the number of drinking friends available.

Socialization influences on continuing to drink.

As non-abstaining, higher level drinkers continue to select more drinking peers, ND and PD continue to impact socialization influences, although the influence of ND and PD become

separate, rather than joint. Similar to the initiation model, PD continues to play an indirect role, in which the number of drinking friends partially explains the negative relationship between PD and binge drinking frequency. As previous studies have reported that rural adolescents have higher rates of alcohol use compared to urban adolescents (Coomber, et al. 2011), the initiation and maintenance socialization models highlight how low PD areas may create an “enhancing” effect. A higher proportion of drinking to abstinent adolescents may facilitate initiation and socialization (full mediation). Once rural adolescents start drinking, low PD indirectly and directly reinforces drinking levels. This, in turn, maintains a high proportion of drinkers to non-drinkers, which increases the likelihood of more adolescent initiation of alcohol use. Unlike the initiation model, ND had no direct effect on binge drinking frequency, and no effect on number of drinking friends for non-abstainers. Additionally, the socialization effect of drinking friends on binge drinking frequency was stronger for individuals in lower, compared to higher ND areas. Taking into account the importance of selecting drinking friends for adolescents in low ND areas, it stands to reason an emphasis on choosing drinking peers will enhance the impact of socialization on maintaining alcohol use. The way that ND may initially influence access to alcohol or drinking peers disappears after adolescents have established a friendship group that emphasizes or includes drinking as a shared activity (Kuntshe et al., 2006), implying that the way ND contextualizes friend socialization of drinking changes along the developmental cascade of initiation to increased drinking behavior.

Limitations and Future Directions.

Our PD and ND census-data variables are from 1990; therefore there is a 5 – 6 year difference between the WI and WII assessments and the actual ND and PD scores. Although there are most likely not drastic differences that could have biased results, it is important to note a substantial increase in overall population from 1990 to 2000 in the United States, which may have changed PD within the 5-year period from 1990 to 1995 (Perry, Mackun, Baker, Joyce, Lollock & Pearson, 2001). With these population changes came regional shifts in income (Deming, 1996). Thus, PD and ND stats derived from 1995 data may have changed results. We were not able to discern if the friends reported by the adolescent were the same friends or different friends at both waves. Although it is possible that changes from WI to WII drinking friends represent “true” selection effects (i.e., seeking out/selecting new friendships based on one’s own behavior), it is also possible that these changes represent a change in friends drinking behavior (e.g., the friends are the same, but the friends are drinking more or less). However, in analyses of Add Health social network data, there is clear evidence for selecting new friends who drink (e.g., Osgood et al., 2013), as well as overall changes to one’s friendship network (e.g., Deutsch et al., 2017). Additionally, although we accounted for clustered, nationally representative data in our analyses, multi-level analyses in which individual alcohol use is nested within neighborhood averages of alcohol use may be able to add additional information (e.g., alcohol use norms based on neighborhood-level alcohol use behavior) that we were not able to analyze. Additional measures of ND that relate to perceptions of neighborhood quality, rather than objective indicators, were not analyzed in the current study, but are also indicated to be important contextual variables (Stanley, Henry & Swaim, 2011; Tucker, Pollard, de la Haye, Kennedy & Green, 2013). Our binge drinking frequency measure was also not gendered – although

operationalizations of binge drinking can have different cutoffs for girls compared to boys (4 vs 5 respectively), we used a 5 – drink cutoff for both genders. We did not account for other specific social influences, such as parents or siblings, that may also be influential; for example, parental monitoring, support, and permissiveness towards alcohol use can vary among high and low ND and PD (Chan et al., 2016; Clark et al., 2011; Chuang 2005). We also did not test for moderation of race, gender, or age; although there are demonstrated differences in all three categories (e.g., older, white adolescents tend to drink more than other demographic groups; Kahn et al., 2016), it is unknown if the ways in which ND and PD relate to socialization or selection differ between demographic groups. Given that Add Health data is from 1995, it is possible that results may differ for more contemporary samples. Finally, we assessed perceived friends, and not actual friends' for measures of peer socialization and selection. However, prior work indicates that, in Add Health, there is little difference in the effect of perceived versus actual friend drinking on drinking behavior (Deutsch, Chernyavskiy, Steinley & Slutske, 2015).

More detailed research probing spatial and social mechanisms of how alcohol use within adolescent social bonds and social functions, through both GIS and social network analysis, may provide a richer systems-level understanding of alcohol use. In particular, understanding how physical space and economic resources shape opportunities for alcohol use via social settings can provide well-needed context to socialization and selection explanations of peer influence. In addition, examining individual characteristics will allow researchers to determine a person $\times$ environment understanding of how specific individuals engage in the opportunities to drink that are provided to them. Rather than conceptualizing peer influence as a count number, examining peer influence as a temporal (e.g., time spent drinking with peers) construct may be more beneficial for specific neighborhoods, which limits the ease of access to numbers of people or opportunities to drink (such as more rural areas).

Cultural, physical, social, and economic characteristics of ND and PD can individually and jointly shape the ways in which adolescents have access both alcohol and drinking friends, and how they relate to them. Although there is substantial research on the peer-adolescent alcohol use association, there is less work on the external contexts that can affect the underlying mechanisms guiding this relationship. Such information is imperative for implementing effective policies and programs focused on reducing and preventing underage drinking.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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A

B

Figure 1A-B.

Three-stage General Joint Analysis Model. Steps for analysis (A): Solid lines indicate Step 1 estimation, long dash lines indicate additional pathways for Step 2 estimation, and short dash lines indicate additional pathways for Step 3 estimation. Example significant moderated mediation model for selection or socialization (B): A significant mediation model (ND predictor-> Drinking friends or alc use mediation-> Drinking friends or alc use outcome) moderated by PD. Black lines indicate required significant pathways, dash lines indicate mediated model pathways. A predictor $\times$ moderator on mediator interaction and a mediator $\times$ moderator on outcome interaction are required.

Note: DF = drinking friends

Figure 2.

Interaction between neighborhood disadvantage and number of drinking friends on WII alcohol use initiation for WI abstainers

Note: Percentages represent averages of neighborhood disadvantage indicator proportions by census block

Figure 3.

Interaction between neighborhood disadvantage and number of drinking friends on WII frequency of binge drinking for WI non-abstainers

Note: Percentages represent averages of neighborhood disadvantage indicator proportions by census block

Figure 4.

Three-way interaction between neighborhood disadvantage, population density, and binge drinking frequency on number of drinking friends for WI non-abstainers.

Note: Percentages represent average proportion of block-level population with neighborhood disadvantage indicators. Low population density represents living in a block-level area with less than 0.01 people per thousand per square kilometer; medium population density represents living in a block-level area with 2 people per thousand per square kilometer, and high population density represents living in a block-level area with 4 people per thousand per square kilometer.

Table 1.

Correlations, means and standard deviations for WI abstainers (top diagonal) and WI non-abstainers (bottom diagonal)

	1	2	3	4	5	6	7	8	9		
1. Drinking Friends WI	-	.32**	0	.12**	.05**	-.03*	.19**	-.01	.01	.01	-.03**
2. Drinking Friends WII	.41**	-	.35**	-.02	-.05**	.14**	-.01	-.06**	-.01	-.01	-.04**
3. Binge Drinking Frequency WI	.42**	.27**	-	0	0	0	0	0	0	0	0
4. Binge Drinking Frequency WII	.31**	.38**	.48**	-	-.02	-.02	.07**	-.06**	-.06**	.03	-.02
5. Neighborhood Disadvantage	-.02	-.09**	-.01**	-.03*	-	.22**	.05**	.02	.36**	.12**	-.12**
6. Population Density	-.08**	-.09**	-.05**	-.07**	.21**	-	.15**	.01	.09**	.29**	.13**
7. Age WI	.19**	.15**	.17**	.16**	.01	.06**	-	-.04*	.03*	.09**	.11**
8. Gender	-.04**	-.05**	-.13**	-.21**	.02	-.01	-.07**	-	.01	.01	-.03
9. Black (vs White)	-.06**	-.10**	-.10**	-.14**	.32**	.06**	.02	.05**	-	-.23**	-.17**
10. Latino/a (vs White)	-.05**	-.05**	-.01	-.01	.10**	.36**	.06**	-.02*	-.21**	-	-.12**
11. Other Race (vs White)	-.05**	-.06**	-.03**	-.04**	-.07**	.12**	.06**	-.01	-.11**	-.11**	-
Mean (SD)											
WI Abstinent	0.43 (0.78)	0.66 (0.95)	0 (0)	0.19 (0.75)	0.17 (0.07)	2.08 (2.92)	14.91 (1.64)	1.52 (0.50)	0.25 (0.43)	0.14 (0.35)	0.08 (0.27)
WI Non-Abstinent	1.55 (1.17)	1.54 (1.19)	1.08 (1.49)	1.67 (1.64)	0.16 (0.06)	1.94 (2.81)	15.65 (1.49)	1.50 (.50)	0.18 (0.38)	0.17 (0.38)	0.05 (0.22)

*
<.05;

**
<.01

Note: Population Density is expressed in 1 per 1000

Table 2.

Odds ratios, beta coefficients^x and confidence intervals for binary logistic regression path model predicting WII initiation for WI abstainers

Drinking Friends WI	M1	M2	M3
Neighborhood Disadvantage	0.91 *** (0.45 – 1.16)	–1.88 *** (–2.05 – –1.60)	–1.92 *** (–2.11 – –1.67)
Population Density	–0.02 * (–0.03 – –0.01)	–0.01 (–0.01 – –0.01)	–0.06 *** (–0.09 – –0.05)
ND × PD	-		0.27 *** (0.22 – 0.49)
Alcohol Initiation WII			
Drinking Friends WI	1.23 *** (1.16 – 1.28)	1.24 ** (1.11 – 1.40)	1.24 * (1.08 – 1.44)
Neighborhood Disadvantage	0.25 ** (0.12 – 0.53)	0.21 ** (0.10 – 0.47)	0.22 ** (0.07 – 0.64)
Population Density	1.00 (0.97 – 1.01)	0.99 (0.97 – 1.02)	0.99 (0.92 – 1.03)
Age	1.07 *** (1.03 – 1.09)	1.05 *** (1.02 – 1.08)	1.05 *** (1.02 – 1.07)
Girls (ref is boys)	1.07 (0.99 – 1.19)	1.06 (0.99 – 1.20)	1.06 (0.99 – 1.19)
African American (ref is European American)	0.77 *** (0.69 – 0.91)	0.78 ** (0.71 – 0.89)	0.78 ** (0.70 – 0.88)
Latino/a (ref is European American)	1.05 (0.93 – 1.20)	1.08 (0.96 – 1.24)	1.08 (0.96 – 1.25)
Other Race/Ethnicity	0.70 ** (0.53 – 0.83)	0.70 ** (0.53 – 0.81)	0.70 ** (0.54 – 0.83)
ND × Drinking Friends	-	2.97 *** (1.76 – 4.08)	3.03 *** (1.89 – 4.12)
PD × Drinking Friends	-	0.99 (0.97 – 1.03)	1.03 (1.00 – 1.10)
ND × PDv	-		1.01 (0.80 – 1.47)
ND × PD × Drinking Friends			0.83 (0.62 – 0.91)

*
p<.05;

**
p<.01;

^x Unstandardized beta coefficients are due to treating the mediating categorical variable as a latent factor

Table 3.

Beta coefficients and confidence intervals for linear regression model predicting binge frequency of drinking within WI non-abstainers

Drinking Friends WI	M1	M2	M3
Neighborhood Disadvantage	0.09 (-0.30 – 0.48)	-0.09 (-0.30 – 0.48)	-0.20 (-0.27 – 0.67)
Population Density	-0.03 *** (-0.04 – 0.01)	-0.03 *** (-0.04 – 0.01)	-0.03 (-0.07 – 0.01)
ND × PD	-	-	-0.07 (-0.28 – 0.14)
Binge Drinking Frequency WII			
Binge Drinking Frequency WI	0.41 *** (0.38 – 0.44)	0.40 *** (0.37 – 0.43)	0.40 *** (0.37 – 0.43)
Drinking Friends WI	0.21 *** (0.17 – 0.25)	0.33 *** (0.24 – 0.42)	0.34 *** (0.24 – 0.44)
Neighborhood Disadvantage	0.21 (-0.56 – 1.00)	1.42 (0.10 – 2.75)	1.48 * (-0.01 – 2.99)
Population Density	-0.03 *** (-0.04 – -0.01)	-0.02 (-0.04 – 0.01)	-0.01 (-0.08 – 0.06)
Age	0.07 *** (0.04 – 0.09)	0.06 *** (0.04 – 0.09)	0.06 *** (0.04 – 0.09)
Girls (ref is boys)	-0.44 *** (-0.54 – -0.34)	-0.44 *** (-0.54 – -0.34)	-0.44 *** (-0.54 – -0.34)
African American (ref is European American)	-0.58 *** (-0.71 – -0.44)	-0.58 *** (-0.72 – -0.45)	-0.59 *** (-0.73 – -0.45)
Latino/a (ref is European American)	-0.05 (-0.18 – 0.09)	-0.06 (-0.19 – 0.08)	-0.06 (-0.19 – 0.08)
Other Race/Ethnicity	-0.44 *** (-0.62 – -0.27)	-0.48 *** (-0.64 – -0.31)	-0.48 *** (-0.64 – -0.31)
ND × Drinking Friends	-	-0.70 * (-1.26 – -0.13)	-0.75 * (-1.39 – -0.11)
PD × Drinking Friends	-	-0.01 (-0.02 – 0.01)	-0.01 (-0.05 – 0.02)
ND × PDv	-	-	-0.03 (-0.38 – 0.31)
ND × PD × Drinking Friends	-	-	0.03 (-0.13 – 0.20)

* $p < .05$;

** $p < .01$;

*** $p < .003$

Table 4.

Incidence rate ratios, beta coefficients^x and confidence intervals for Poisson regression path model predicting number of drinking friends within WI non-abstainers

Binge Drinking Frequency WI	M1	M2	M3
Neighborhood Disadvantage	0.23 (-0.52 – 0.96)	0.22 (-0.52 – 0.97)	0.33 (-0.55 – 1.21)
Population Density	-0.03 [*] (-0.07 – -0.01)	-0.03 [*] (-0.04 – -0.01)	-0.01 (-0.06 – 0.04)
ND × PD			-0.06 (-0.27 – 0.15)
Drinking Friends WII			
Binge Drinking Frequency WI	1.04 ^{***} (1.03 – 1.06)	1.06 ^{***} (1.03 – 1.09)	1.02 (0.99 – 1.06)
Drinking Friends WI	1.25 ^{***} (1.23 – 1.28)	1.25 ^{***} (1.23 – 1.28)	1.25 ^{***} (1.22 – 1.28)
Neighborhood Disadvantage	0.47 ^{***} (0.31 – 0.71)	0.55 [*] (0.35 – 0.84)	0.37 ^{***} (0.23 – 0.60)
Population Density	1.00 (0.99 – 1.00)	1.00 (0.99 – 1.01)	0.95 ^{**} (0.93 – 0.98)
Age	1.04 ^{***} (1.02 – 1.05)	1.04 ^{***} (1.02 – 1.05)	1.04 ^{***} (1.02 – 1.05)
Girls (ref is boys)	0.99 (0.96 – 1.03)	0.99 (0.96 – 1.03)	0.99 (0.96 – 1.03)
African American (ref is European American)	0.89 ^{***} (0.84 – 0.94)	0.87 ^{***} (0.83 – 0.94)	0.89 ^{***} (0.84 – 0.94)
Latino/a (ref is European American)	0.98 (0.92 – 1.03)	0.98 (0.92 – 1.04)	0.98 (0.92 – 1.04)
Other Race/Ethnicity	0.82 [*] (0.71 – 0.94)	0.82 [*] (0.71 – 0.94)	0.83 [*] (0.73 – 0.95)
ND × Drinking Friends		1.00 (1.00 – 1.01)	1.09 (0.90 – 1.30)
PD × Drinking Friends		0.91 (0.78 – 1.06)	1.02 [*] (1.01 – 1.04)
ND × PD			1.23 ^{***} (1.10 – 1.39)
ND × PD × Drinking Friends			0.90 [*] (0.84 – 0.97)

^{*}
 $p < .05$;

^{**}
 $p < .01$;

^{***}
 $p < .003$

^x Unstandardized beta coefficients are due to treating the mediating categorical variable as a latent factor