

## Original Article

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# The association between neighborhood-level social fragmentation and distressing psychotic-like experiences in early adolescence: the moderating role of close friends

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**Abstract**

**Background.** Early exposure to neighborhood social fragmentation has been shown to be associated with schizophrenia. The impact of social fragmentation and friendships on distressing psychotic-like experiences (PLE) remains unknown. We investigate the relationships between neighborhood social fragmentation, number of friends, and distressing PLE among early adolescents.

**Methods.** Data were collected from the Adolescent Brain Cognitive Development Study. Generalized linear mixed models tested associations between social fragmentation and distressing PLE, as well as the moderating role of the number of total and close friends.

**Results.** Participants included 11 133 adolescents aged 9 to 10, with 52.3% being males. Greater neighborhood social fragmentation was associated with higher levels of distressing PLE (adjusted  $\beta = 0.05$ ; 95% CI: 0.01–0.09). The number of *close* but not total friends significantly interacted with social fragmentation to predict distressing PLE (adjusted  $\beta = -0.02$ ; 95% CI:  $-0.04$  to  $<-0.01$ ). Among those with fewer close friends, the association between neighborhood social fragmentation and distressing PLE was significant (adjusted  $\beta = 0.07$ ; 95% CI: 0.03–0.11). However, among those with more close friends, the association was non-significant (adjusted  $\beta = 0.03$ ; 95% CI:  $-0.01$  to 0.07).

**Conclusions.** Greater neighborhood social fragmentation is associated with higher levels of distressing PLE, particularly among those with fewer close friends. Further research is needed to disentangle aspects of the interaction between neighborhood characteristics and the quality of social interactions that may contribute to psychosis, which would have implications for developing effective interventions at the individual and community levels.

**Introduction**

Psychotic-like experiences (PLE) are one of the earliest manifestations of subclinical psychotic symptoms, and about 17% of early adolescents aged 9 to 12 years have reported PLE (Kelleher et al., 2012). In addition, greater distress associated with PLE has been shown to be associated with an increased risk of later mental disorders, including psychotic disorders, major depressive disorders, bipolar disorders, and anxiety disorders among adults and adolescents (Dominguez, Wichers, Lieb, Wittchen, & van Os, 2011; Healy et al., 2019; Mcgrath et al., 2016; Trotta et al., 2020). Considering the high prevalence of PLE in early adolescents and its clinical significance with respect to the later risk of psychosis and mental disorders in general, exploring the risk factors for distressing PLE itself would be critical to better understand and evaluate psychiatric risk among children and adolescents, which would have implications for designing effective strategies to prevent and mitigate poor outcomes later in life.

Recent studies on the etiology of PLE suggest that environmental factors may play a greater role than genetic factors (Taylor, Freeman, Lundström, Larsson, & Ronald, 2022). Risk factors for PLE include younger age (Creatura, Ered, Murty, & Elluman, 2022), male sex (Creatura et al., 2022), lower socioeconomic status (Oh et al., 2022), adverse social life events (Arseneault et al., 2011; Kelleher et al., 2013), and ethnic minority status (Varchmin, Montag, Treusch, Kaminski, & Heinz, 2021). Among these environmental factors, social adversity has been one of the greatest risk factors for psychosis (Varchmin et al., 2021). While most prior research on the emergence of adolescent PLE has focused on individual-level

risk factors, little is currently known about the potential impact of neighborhood-level social processes such as social fragmentation.

Neighborhood-level social fragmentation, defined as the disruption of social ties and relationships among residents and families in communities, has been shown to be associated with greater schizophrenia rates (Allardyce et al., 2005; Pignon, Szoke, Ku, Melchior, & Schurhoff, 2023). Several variables have been used to measure childhood exposure to social fragmentation, such as transiency (as measured by the percentage of renter-occupied housing or owner-occupied housing (reversed)) (Jongsma et al., 2018; Ku et al., 2023a; Silver, Mulvey, & Swanson, 2002) and non-nuclear families (as measured by the percentage of single-parent households) (Ku et al., 2023a; Zammit et al., 2010). This construct is based on Social Disorganization Theory, which posits that social processes within communities, such as social cohesion, social norms, and collective efficacy, are likely structural factors that contribute to the promotion of children's development and health (Flouri, Midouhas, Joshi, & Sullivan, 2015; Robert & Groves, 1989). Neighborhood-level social fragmentation is an inversely related but distinct characteristic that captures the disruption of social ties.

Repetitive and chronic adverse social stressors linked to structural aspects of one's community and poor peer relationships may result in a decline in social functioning, which has been shown to predict conversion to psychosis among youth at high-risk (Addington et al., 2017; Jang et al., 2011). Exposure to greater area-level social fragmentation during childhood has been associated with greater maladaptation to the social environment, which in turn is related to poorer social functioning in adulthood, particularly among youth at clinical high risk for psychosis (CHR-P) (Ku et al., 2023a). Perhaps early deprivation from socially connected communities due to living in fragmented neighborhoods may also impact the development of distressing PLE. However, the relationship between neighborhood social fragmentation and these early manifestations of subclinical psychosis is unknown. In addition, protective factors for PLE among early adolescents growing up in socially fragmented communities have yet to be explored.

Emerging literature demonstrates that social connectedness is associated with many important health outcomes, including mortality (Holt-Lunstad, Robles, & Sbarra, 2017; Joshi et al., 2023). In addition, the quality and quantity of social relationships may buffer the impact of adversity on the brain and behavior. Our previous findings suggest that social engagement may buffer the deleterious effect of living in poor neighborhoods on the reduction of hippocampal volume among youth at clinical high risk for psychosis (Ku et al., 2022). Another study identified involvement in sports to be protective against psychotic symptoms in the general population (Keskinen et al., 2018). A recent study found that a greater number of close friends attenuated the association between ethnic minority status and PLE (Karcher et al., 2022).

It may be possible that greater number of friends may also attenuate the adverse impact of social fragmentation on psychosis. However, the associations between social fragmentation, friendships, and distressing PLE have yet to be examined. In this study, we constructed neighborhood-level social fragmentation as a rough proxy to estimate the disruption of social ties and relationships among residents and families in a community based on prior literature (Ku, Compton, Walker, & Druss, 2021). As done previously, we operationalized exposure to area-level social fragmentation as living in communities with greater transiency (percentage of residents with non-owner-occupied housing) and

non-nuclear families (percentage of single-parent households). This study investigated whether (1) neighborhood-level social fragmentation was associated with distressing PLE among early adolescents and whether the number of (2) friends and (3) close friends would moderate any observed relationship between social fragmentation and distressing PLE.

## Methods

### Participants

Participants were recruited between June 1, 2016 and October 15, 2018 into the Adolescent Brain Cognitive Development (ABCD) Study version 4.0 (Paul et al., 2021). The ABCD Study is a large-scale research project funded by the US National Institutes of Health to study adolescent brain development. In this study, 21 research sites across the country recruited over 11 000 children aged 9–10 and tracked their physical and behavioral development into adulthood (Casey et al., 2018). Centralized institutional review board approval was obtained from the University of California, San Diego. Written informed consent and assent were obtained from a parent or guardian and the child, respectively, to participate in the ABCD Study.

In this analysis, we excluded participants with missing data on exposure, outcome, or covariates of interest. The inclusion and exclusion criteria reduced our sample size from  $n = 11\,876$  to  $n = 11\,133$ . A comparison of characteristics between participants included in this analysis and those excluded is shown in online Supplementary Table S1.

### Sociodemographic characteristics

Sociodemographic characteristics were obtained from self-report and interview-based measures at the time of baseline assessment, including age, sex, parental education, race/ethnicity, and family history of psychosis. Greater parental education indicates whether the parent or caregiver completed high school. Family history of psychosis was obtained from the ABCD Family History Assessment and indicated whether any of the participant's first-degree relatives ever had a period lasting six months or more when they experienced psychosis (e.g. saw visions or heard voices or thought people were spying on them or plotting against them).

### Psychotic-like experiences

This study used the Prodromal Questionnaire-Brief Child Version (PQ-BC) to evaluate distressing PLE. The PQ-BC is a self-report questionnaire with 21 questions asking about psychotic-like symptoms. Examples of items are as follows: 'Did places that you know well, such as your bedroom, or other rooms in your home, your classroom or schoolyard, suddenly seem weird, strange or confusing to you; like not the real world?' and 'Did you suddenly start to be able to see things that other people could not see or they did not seem to see?' Of the 11 133 participants included in our analysis, 61.0% ( $N = 6790$ ) reported having at least one PLE. This is comparable to a recent study showing that 51.6% ( $N = 678$ ) of young adults aged 19 to 35 from a nationally representative survey of the Finnish population reported having at least one PLE (Lindgren, Numminen, Holm, Therman, & Tuulio-Henriksson, 2022).

Distressing PLE scores were weighted sum scores of the 21 questions according to distress level (i.e. 0 for no, 1 for yes

without distress, and 2 to 6 for yes with a distress score of 1 or more; total range 0 to 126) and the scale for rating distressing PLE scores was previously described (Karcher et al., 2018; Loewy, Pearson, Vinogradov, Bearden, & Cannon, 2011). The distressing PLE score had a highly skewed distribution of 3.027. Because this value is greater than 1.5 (Tabachnick & Fidell, 2013), we log-transformed this variable,  $\text{Log}_{10}(X + 1)$ , as done in a prior study (Karcher et al., 2018), which reduced the skewness to 0.585 (online Supplementary Fig. S1).

### Neighborhood characteristics

Neighborhood-level characteristics were derived from baseline primary home addresses, which were included in the ABCD assessments of primary residential history. Parents/caregivers of participants provided their primary addresses; the first address was geo-coded to census tract-level data. Neighborhood characteristics were derived from the American Community Survey 5-year summary estimates (average annual estimates spanning 2010–2014) before participant recruitment and were deemed to approximate participants' living environment. Neighborhood social fragmentation has been operationalized by transiency and non-nuclear families in the community (Allardyce & Boydell, 2006; Ku et al., 2021). In this study, exposure to neighborhood social fragmentation during childhood and adolescence was measured by the average of the z-scores of the percent of residents with non-owner-occupied housing (Jongsma et al., 2018; Silver et al., 2002) and the percent of single-parent households (Ku et al., 2023a; Zammit et al., 2010). Neighborhood poverty was defined as the percentage of families living below the poverty level. Neighborhood-level population density was defined as the number of people living in a census tract. It was obtained from the Smart Location Database created by the United States Environmental Protection Agency based on the 2010 Census Data (Fan et al., 2021).

### The number of total and close friends

The number of total and close friends was derived from the ABCD Other Resilience survey to assess the potential moderating role of friends (Hoffman et al., 2019) on the relationship between social fragmentation and distressing PLE. Participants in the survey were asked to self-report on the number of male and female friends as well as the number of male and female close friends they have. We summed up the number of reported male and female friends to generate the number of total and close friends. Descriptive statistics on the distribution of these variables are shown in online Supplementary Fig. S2.

### Data analysis

Generalized linear mixed models were fitted with social fragmentation as the independent variable and distressing PLE as the dependent variable. Because individuals were clustered within families and sites, the model added family groups and sites as two separate random intercepts. We then adjusted for the following eight covariates as fixed effects, which have been shown in prior literature to be associated with increased risk for psychosis and PLE: younger age (Creatura et al., 2022), male sex (Creatura et al., 2022), ethnoracial minority status (Varchmin et al., 2021), lower parental education (Oh et al., 2022), immigrant status (Brandt et al., 2019), family history of psychosis (Lu et al.,

2018), neighborhood-level poverty (O'Donoghue, Roche, & Lane, 2016), and neighborhood-level population density (Pignon et al., 2023).

Bivariate correlations assessed the relationships between independent variables, and the variance inflation factors of less than five ruled out multicollinearity in these models (Simko, 2021). To test the potential moderating roles of the number of friends and close friends on the relationship between social fragmentation and distressing PLE, we included social fragmentation-by-friends and social fragmentation-by-close friends as interaction terms in two separate models. We also tested the potential moderating roles of age, male sex, greater parental education, White non-Hispanic race/ethnicity, and born in the US with interaction terms. For each significant interaction term, we conducted a simple slope analysis to test for the differences in the relationship between neighborhood social fragmentation and distressing PLE by  $-1$  standard deviation (s.d.), average, and  $+1$  s.d. of the moderator (Aiken, West, & Reno, 1991). Statistical analyses were performed using R (Version 4.2.1).

## Results

### Descriptive statistics

This study included 11 133 adolescents aged 9 to 10 years, with 5828 (52.3%) males, 7115 (63.9%) White participants, and 930 (8.4%) with a family history of psychosis (Table 1). Forty participants were excluded due to missing data – those excluded were more likely to have greater distressing PLE, have parents without a high school diploma, and live in a poor neighborhood (online Supplementary Table S1). Neighborhood-level social fragmentation was positively correlated with ethnoracial minority status, lower parental education, being born in the US, having a family history of psychosis, greater levels of neighborhood poverty, and greater neighborhood-level population density (Table 2).

### Generalized linear mixed models with distressing PLE as the outcome

Greater neighborhood-level social fragmentation was significantly associated with distressing PLE (unadjusted  $\beta = 0.13$  95% CI: 0.11–0.16;  $p < 0.001$ ) even after adjusting for the eight covariates (adjusted  $\beta = 0.05$ ; 95% CI: 0.01–0.09;  $p = 0.008$ ) (Table 3). In an unadjusted model, the covariate, neighborhood-level population density, was significantly associated with greater distressing PLE (unadjusted  $\beta = 0.04$ ; 95% CI: 0.02–0.06;  $p < 0.001$ ), but the relationship was no longer significant after adjusting for other covariates (adjusted  $\beta = -0.01$ ; 95% CI:  $-0.04$  to  $0.01$ ;  $p = 0.318$ ). As expected, other covariates in the adjusted model – including male sex, ethnoracial minority status, family history of psychosis, and living in a poor neighborhood – were associated with greater distressing PLEs.

### Potential moderators

In this study, participants had a median of 14 total and four close friends. The number of total friends did not significantly interact with social fragmentation in predicting distressing PLE (unadjusted  $\beta = -0.01$ ; 95% CI:  $-0.03$  to  $0.01$ ;  $p = 0.146$ ) (Table 4). However, the number of close friends significantly interacted with social fragmentation in predicting distressing PLE even after adjusting for the eight covariates (adjusted  $\beta =$

**Table 1.** Baseline sociodemographic characteristics

Sample size <i>N</i>	11 133
Age (median [IQR])	9.92 [9.33–10.50]
Male (%)	5828 (52.3)
Race	
White (%)	7115 (63.9)
Black (%)	1689 (15.2)
Asian (%)	261 (2.3)
Native American/ Pacific Islander (%)	73 (0.7)
Other (%)	610 (5.5)
Multi-race (%)	1385 (12.4)
Hispanic/Latino (%)	2253 (20.2)
Parents with high school diploma or greater (%)	9544 (85.7)
Born in the US (%)	10 785 (96.9)
Family history of psychosis (%)	930 (8.4)
Percentage of families below the poverty level (median [IQR])	7.15 [3.19–15.81]
Neighborhood-level population density (median [IQR])	1669.99 [806.15–2812.42]
Neighborhood-level social fragmentation	
Percentage of single parents (median [IQR])	14.38 [8.92–23.47]
Percentage of house owner (median [IQR])	69.96 [50.27–83.50]
PQBC distress score (median [IQR])	1.00 [0.00–6.00]
Friends (median [IQR])	14.00 [8.00–24.00]
Close friends (median [IQR])	4.00 [3.00–7.00]

–0.02; 95% CI: –0.04 to <–0.01; *p* = 0.022) (Table 4). Among those with fewer (–1 s.d.) and average number of close friends, the association between neighborhood social fragmentation and distressing PLE was significant (adjusted  $\beta$  = 0.07; 95% CI: 0.03–0.11, *p* < 0.001 and adjusted  $\beta$  = 0.05; 95% CI: 0.01–0.09, *p* = 0.009, respectively). However, among those with more close friends (+1 s.d.), the association was non-significant (adjusted  $\beta$  = 0.03; 95% CI: –0.01 to 0.07, *p* = 0.158) (Fig. 1).

Other potential moderators, including age, male sex, White non-Hispanic race/ethnicity, and born in the US, did not significantly interact with neighborhood social fragmentation in predicting distressing PLE (online Supplementary Table S2).

### Discussion

This study is the first to show that greater neighborhood social fragmentation is associated with higher levels of distressing PLE above and beyond other individual-level and neighborhood-level characteristics relevant to psychosis. This finding builds upon previous findings showing that indices of area-level social fragmentation are associated with a higher prevalence of psychotic disorders (Ku et al., 2021), earlier age at onset of psychosis among those with first-episode psychosis (Ku, Pauselli, Manseau, & Compton, 2020), and conversion to psychosis among those at clinical high risk (Ku et al., 2021). The association between neighborhood-level population density and distressing PLE is

**Table 2.** Bivariate correlations

	Age	Male sex	White non-Hispanic	Greater parental education	Born in the US	Family history of psychosis	Neighborhood-level poverty	Neighborhood-level population density
Male sex	0.018							
White non-Hispanic	0.026**	0.017						
Greater parental education	0.011	0.019*	0.238**					
Born in the US	–0.006	–0.009	–0.115**	–0.023*				
Family history of psychosis	–0.009	–0.006	–0.040**	–0.023*	–0.021*			
Neighborhood-level poverty	–0.037**	–0.011	–0.422**	–0.276**	0.001	0.051**		
Neighborhood-level population density	0.001	–0.009	–0.254**	–0.170**	0.067**	0.006	0.273**	
Neighborhood-level social fragmentation	–0.030**	–0.016	–0.450**	–0.249**	0.021*	0.049**	0.832**	0.386**

\* = Correlation is significant at *p* < 0.05.

\*\* = Correlation is significant at *p* < 0.01.

Note: Pearson's correlation was used between continuous variables, Cramer's V was used between categorical variable (e.g. sex, race/ethnicity, and family history of psychosis), and point-biserial correlation was used between continuous and categorical variables.

**Table 3.** Univariate and multivariable models predicting distressing psychotic-like experiences

Parameters	Univariate				Multivariable			
	$\beta$	s.e.	95% CI	<i>p</i>	$\beta$	s.e.	95% CI	<i>p</i>
Age	<b>-0.06</b>	<b>0.01</b>	<b>-0.08 to -0.04</b>	<b>&lt;0.001</b>	<b>-0.06</b>	<b>0.01</b>	<b>-0.08 to -0.04</b>	<b>&lt;0.001</b>
Male sex	<b>0.07</b>	<b>0.02</b>	<b>0.04 to 0.11</b>	<b>&lt;0.001</b>	<b>0.08</b>	<b>0.02</b>	<b>0.04 to 0.11</b>	<b>&lt;0.001</b>
White non-Hispanic	<b>-0.28</b>	<b>0.02</b>	<b>-0.32 to -0.24</b>	<b>&lt;0.001</b>	<b>-0.21</b>	<b>0.02</b>	<b>-0.26 to -0.17</b>	<b>&lt;0.001</b>
Greater parental education	<b>-0.22</b>	<b>0.04</b>	<b>-0.30 to -0.13</b>	<b>&lt;0.001</b>	-0.06	0.05	-0.15 to 0.03	0.164
Born in the US	-0.09	0.05	-0.20 to 0.01	0.086	<b>-0.13</b>	<b>0.05</b>	<b>-0.23 to -0.02</b>	<b>0.017</b>
Family history of psychosis	<b>0.14</b>	<b>0.03</b>	<b>0.08 to 0.21</b>	<b>&lt;0.001</b>	<b>0.11</b>	<b>0.03</b>	<b>0.05 to 0.18</b>	<b>&lt;0.001</b>
Neighborhood-level poverty	<b>0.12</b>	<b>0.01</b>	<b>0.10 to 0.14</b>	<b>&lt;0.001</b>	<b>0.04</b>	<b>0.02</b>	<b>0.01 to 0.08</b>	<b>0.017</b>
Neighborhood-level population density	<b>0.04</b>	<b>0.01</b>	<b>0.02 to 0.06</b>	<b>&lt;0.001</b>	-0.01	0.01	-0.04 to 0.01	0.318
Neighborhood-level social fragmentation	<b>0.13</b>	<b>0.01</b>	<b>0.11 to 0.16</b>	<b>&lt;0.001</b>	<b>0.05</b>	<b>0.02</b>	<b>0.01 to 0.09</b>	<b>0.008</b>
Intraclass correlation of family groups					44.9%			
Intraclass correlation of sites					25.1%			
Pseudo- $R^2$ (Total)					33.2%			

Note: Neighborhood-level social fragmentation is the main independent variable denoted by gray shading.

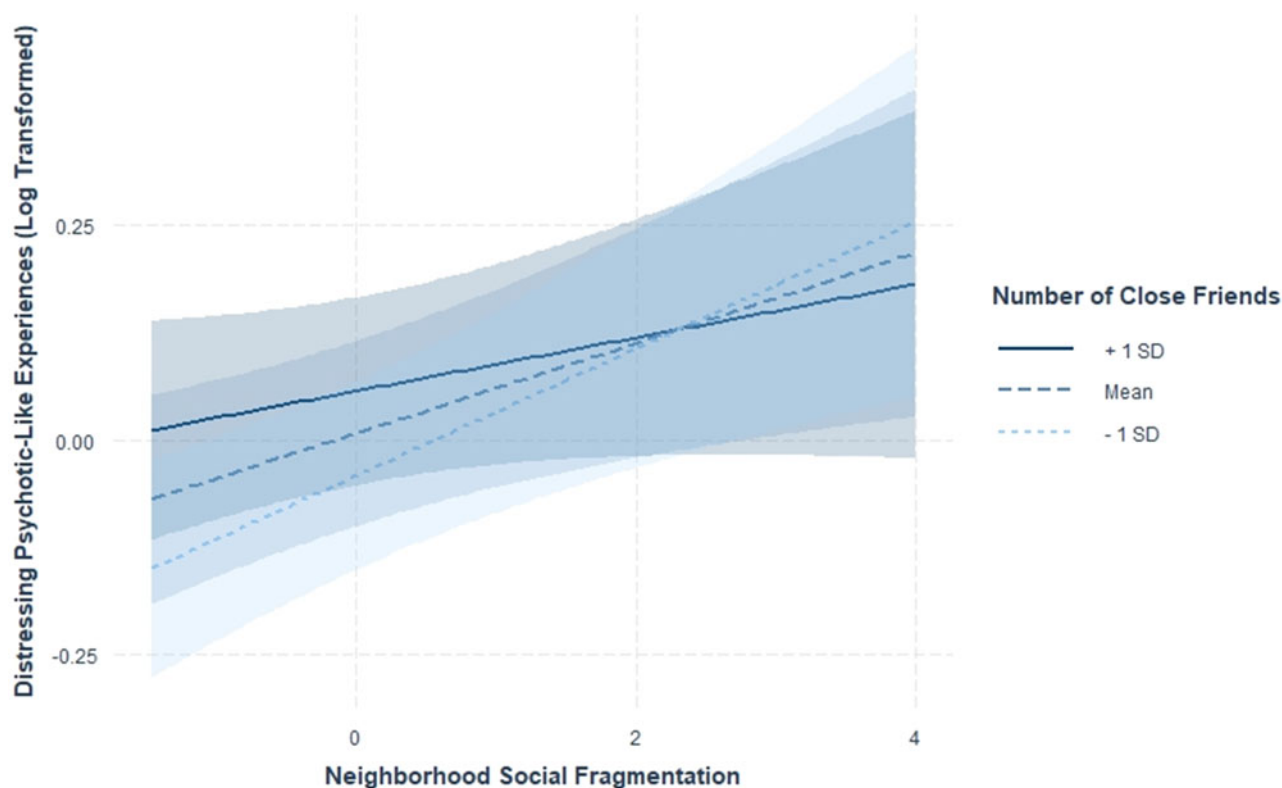
**Table 4.** Adjusted models with number of close friends and total friends interaction terms predicting distressing psychotic-like experiences

Parameters	Interaction model including close friends				Interaction model including total friends			
	$\beta$	s.e.	95% CI	<i>p</i>	$\beta$	s.e.	95% CI	<i>p</i>
Age	<b>-0.06</b>	<b>0.01</b>	<b>-0.08 to -0.04</b>	<b>&lt;0.001</b>	<b>-0.06</b>	<b>0.01</b>	<b>-0.08 to -0.04</b>	<b>&lt;0.001</b>
Male sex	<b>0.08</b>	<b>0.02</b>	<b>0.04 to 0.12</b>	<b>&lt;0.001</b>	<b>0.08</b>	<b>0.02</b>	<b>0.04 to 0.11</b>	<b>&lt;0.001</b>
White non-Hispanic	<b>-0.21</b>	<b>0.02</b>	<b>-0.26 to -0.17</b>	<b>&lt;0.001</b>	<b>-0.21</b>	<b>0.02</b>	<b>-0.26 to -0.17</b>	<b>&lt;0.001</b>
Greater parental education	-0.06	0.05	-0.15 to 0.03	0.164	-0.07	0.05	-0.16 to 0.02	0.135
Born in the US	<b>-0.13</b>	<b>0.05</b>	<b>-0.24 to -0.03</b>	<b>0.015</b>	<b>-0.13</b>	<b>0.05</b>	<b>-0.24 to -0.03</b>	<b>0.013</b>
Family history of psychosis	<b>0.12</b>	<b>0.03</b>	<b>0.05 to 0.18</b>	<b>&lt;0.001</b>	<b>0.11</b>	<b>0.03</b>	<b>0.05 to 0.18</b>	<b>&lt;0.001</b>
Neighborhood-level poverty	<b>0.04</b>	<b>0.02</b>	<b>0.01 to 0.08</b>	<b>0.014</b>	<b>0.04</b>	<b>0.02</b>	<b>0.01 to 0.08</b>	<b>0.013</b>
Neighborhood-level population density	-0.01	0.01	-0.04 to 0.01	0.309	-0.01	0.01	-0.04 to 0.01	0.326
Neighborhood-level social fragmentation	<b>0.05</b>	<b>0.02</b>	<b>0.01 to 0.09</b>	<b>0.009</b>	<b>0.05</b>	<b>0.02</b>	<b>0.01 to 0.09</b>	<b>0.008</b>
Close friends	<b>0.05</b>	<b>0.01</b>	<b>0.03 to 0.07</b>	<b>&lt;0.001</b>				
Neighborhood-level social fragmentation-by-close friends	<b>-0.02</b>	<b>0.01</b>	<b>-0.04 to &lt;-0.01</b>	<b>0.022</b>				
Total friends					<b>0.05</b>	<b>0.01</b>	<b>0.03 to 0.07</b>	<b>&lt;0.001</b>
Neighborhood-level social fragmentation-by-total friends					-0.02	0.01	-0.04 to <0.01	0.111
Intraclass correlation of family groups	24.2%				24.4%			
Intraclass correlation of sites	6.6%				6.5%			
Pseudo- $R^2$ (Total)	33.3%				33.1%			

Note: The interaction terms are the main independent variables denoted by gray shading.

no longer significant in multivariable models adjusting for social fragmentation and individual-level indices of socioeconomic status, which is consistent with prior studies demonstrating that

area-level social fragmentation partially explains the relationship between urbanicity and psychosis (March et al., 2008; O'Donoghue et al., 2016; Zammit et al., 2010).



**Figure 1.** The interaction term, neighborhood social fragmentation-by-the number of close friends, was significantly associated with distressing PLE (adjusted  $\beta = -0.02$ , 95% CI:  $-0.04$  to  $<-0.01$ ,  $p = 0.022$ ). The model adjusted for age, male sex, White non-Hispanic race/ethnicity, greater parental education, born in the US, family history of psychosis, neighborhood-level poverty, and neighborhood-level population density. Simple slopes were calculated to further probe the significant interaction term. Fewer number of closer friends ( $-1$  s.d.): adjusted  $\beta = 0.07$ ; 95% CI:  $0.03$  to  $0.11$ ,  $p < 0.001$ . Average number of close friends: adjusted  $\beta = 0.05$ ; 95% CI:  $0.01$  to  $0.09$ ,  $p = 0.009$ . Greater number of close friends ( $+1$  s.d.): adjusted  $\beta = 0.03$ ; 95% CI:  $-0.01$  to  $0.07$ ,  $p = 0.158$ .

This study also finds that the number of close friends significantly moderates the relationship between neighborhood social fragmentation and distressing PLE. Among those with more close friends, the relationship between neighborhood social fragmentation and distressing PLE is not significant. However, this relationship is significant among those with fewer close friends, and the effect size was slightly larger than the main effect. Interestingly, the number of total friends is not a significant moderator, suggesting that the quality and nature of friends may matter in its potential buffering effect on the association between the social environment and distressing PLE.

Our findings on the associations among neighborhood social fragmentation, number of friends, and distressing PLE build upon Social Disorganization Theory and literature regarding the social determinants of psychosis (Anglin et al., 2021; Robert & Groves, 1989). The social environment is crucial for children's mental health, and disruption to social ties can have long-lasting detrimental effects on mental health (Kawachi & Berkman, 2001). Disruption of social bonds and connections within the community may have downstream effects at the individual level (Bronfenbrenner & Ceci, 1994). For example, neighborhoods with greater transiency and single-parent households tend to have more children with deviant behavior (Dornbusch et al., 1985; Steinberg, 1987), leading to peer victimization or bullying at school, which in turn may lead to the development of greater mental health-related distress (Schreier et al., 2009).

Recent literature suggests that early exposure to social adversity may have a greater impact on psychosis onset than later exposure

to adversity (Lataster, Myin-Germeys, Lieb, Wittchen, & van Os, 2012). Residential instability (defined by a greater number of moves) during childhood and adolescence was strongly correlated in a dose-response fashion with later risk for non-affective psychosis, while there was weaker evidence that moving during adulthood was associated with psychosis risk (Price, Dalman, Zammit, & Kirkbride, 2018). The association between residential instability during adolescence and earlier age at onset of psychosis in young adults with first-episode psychosis was shown to be moderated by extroversion, such that higher extroversion seemed to buffer the effect of residential instability on psychosis risk (Ku, Walker, Druss, Murray, & Compton, 2023b). Extroversion may lead to making more close friends, which could buffer the deleterious effects of neighborhood-level social fragmentation on distressing PLE. Alternatively, extroversion or other influences (i.e. self-esteem) may play a more crucial role in buffering the adverse effects of social stressors on psychopathology.

This study has several limitations. First, this is a cross-sectional study, and we cannot draw causal inferences. It could be possible that families with more genetic liability for distressing PLE live in neighborhoods with greater social fragmentation. Second, it is unclear what the subjective experiences and circumstances of participants living in neighborhoods with greater 'social fragmentation' are in this study. Nevertheless, this empirical construct based on a theoretical framework is a predictor of non-affective psychotic disorders and has recently been shown to be related to subjective feelings of maladjustment in schools during childhood (Ku et al., 2023a). However, more studies are needed to

unpack the mechanisms of how social fragmentation may relate to psychosis. Third, it is unclear whether the length of exposure to social fragmentation at specific places would impact PLE. In addition, neighborhood characteristics were estimated based on census data from a few years before the start of the recruitment of participants in this study, and the extent to which participants were exposed to these characteristics is unknown. Thus, more precise measures that reflect participants' actual, rather than approximated, exposures to their social environments are needed. Fourth, the number of friends was self-reported and could have been affected by recall error or social desirability bias. Future studies should incorporate other methods to assess the quality and quantity of friends. Fifth, the forty participants excluded from this study due to missing data had greater distressing PLE, which may impact the generalizability of the findings. Based on the pattern of missing data with those at greatest risk being underrepresented, a likely consequence was that the statistical tests underestimated the strength of relationships (Wolke et al., 2009). Sixth, it is still unclear if there is a sensitive developmental time in which the impact of social fragmentation may be most salient on PLE. Prior literature suggests that adversity may impact the risk for psychosis more in childhood compared to later in adulthood. However, whether the association between neighborhood-level social fragmentation and PLE may differ depending on the exposure timing is unclear.

In conclusion, our results demonstrate that living in neighborhoods with greater social fragmentation is associated with higher levels of distressing PLE, and the number of close friends moderates this relationship. This study furthers the understanding of the etiology of psychotic disorders as it pertains to neighborhood-level social factors and peer relationships. Future studies should assess the quality and nature of close friends (e.g. psychological support, rule-breaking/delinquent behaviors) and how these factors may interact with neighborhood-level characteristics in impacting the developmental trajectories of distressing PLE. If these findings are replicated in a causal framework over time, possible implications of this line of research would be (1) identifying at-risk groups (e.g. those living in neighborhoods with high levels of social fragmentation who also lack close friends) and (2) supporting interventions that foster close peer relationships. A recent review described a few studies demonstrating that adolescent friendship-building interventions improved mental health, well-being, and social connectedness (Boda, Elmer, Voros, & Stadtfeld, 2020; Haslam, Cruwys, Haslam, Dingle, & Chang, 2016). Perhaps these interventions may also be adapted to prevent distressing PLE among at-risk youth who lack close friends and live in socially fragmented neighborhoods. Further research on the causal mechanisms of the relationships among neighborhood characteristics, close friends, and distressing PLE is needed to design a feasible and effective intervention to offset the risk of psychosis among these at-risk youth.

**Supplementary material.** The supplementary material for this article can be found at <https://doi.org/10.1017/S0033291724000278>

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**Competing interests.** None.

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