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Neighborhood disorder and glycemic control in late adolescents with Type 1 diabetes

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Abstract

Objective—To evaluate the contribution of neighborhood characteristics to treatment adherence and glycemic control in late adolescents with Type 1 diabetes.

Research Design and Methods—As part of a larger study, 220 late adolescents with Type 1 diabetes (aged 17.8 ± 0.4 years, 59.6% female, diabetes duration 7.3 ± 3.9 years) were recruited from outpatient pediatric clinics during their senior year of high school. Adolescents completed self-report measures of adherence behaviors and subjective social status, and their HbA1c values were collected during a lab assessment. Their mothers reported on their own educational achievement. These data were linked with neighborhood characteristics obtained from 2010 American Community Survey data using participants' home addresses. Based on previous work (Dulin-Keita, Casazza, Fernandez, Goran, & Gower, 2012), a neighborhood disorder composite score was computed from Census-tract-level variables, including percent of the population achieving less than a high school education, under 18 who lived in poverty, unemployed, receiving public assistance, and percent of households that were vacant.

Results—Adolescents with Type 1 diabetes who lived in more disordered neighborhoods were at higher risk for poorer glycemic control ($p < .001$), but did not report poorer adherence behaviors. The association between neighborhood disorder and HbA1c was significant after accounting for family socioeconomic status (maternal education), but not subjective social status.

Conclusions—Results highlight the importance of neighborhood disorder for adolescents' glycemic control. The nonsignificant association between neighborhood disorder and adherence behaviors suggests physiological rather than behavioral mechanisms may be driving neighborhood SES-health outcome links.

Keywords

Neighborhood Disorder; Adolescents; Type 1 Diabetes; Subjective Social Status

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Introduction

Characteristics of individuals' neighborhoods have important implications for their health. Neighborhood characteristics, including poverty rates and educational achievement, have been linked to such health indicators as cortisol levels (Dulin-Keita, Casazza, Fernandez, Goran, & Gower, 2012; Karb, Elliott, Dowd, & Morenoff, 2012), blood pressure, and BMI (Chen & Paterson, 2006). Neighborhood characteristics may also be associated with aspects of Type 1 diabetes management. Those living in less advantaged neighborhoods typically have limited access to health care, healthy foods, and safe recreation areas (Diez Roux, 2001; Steptoe & Feldman, 2001), and have higher levels of chronic stress (Leventhal & Brooks-Gunn, 2000; Steptoe et al., 2001; Xue, Leventhal, Brooks-Gunn, & Earls, 2005), all of which may have implications for Type 1 diabetes management. These neighborhood characteristics reflect stressful experiences that may be associated with poorer glycemic control, though it is uncertain as to whether these experiences directly influence the neuroendocrine system or if they alter glycemic control through poorer adherence behaviors (Lloyd et al., 1999). Although links have been established between various social resources (e.g., income, parental education; Borschuk & Everhart, 2015; Naar-King, Podolski, Ellis, Frey, & Templin, 2006) and diabetes management, the role of the larger neighborhood environment has not been considered. It is important to understand if adolescents in disordered neighborhoods exhibit different glycemic control compared to adolescents in more ordered neighborhoods to illuminate the likely mechanisms for disparities in diabetes trajectories for these cohorts. The goal of the present study was to examine the contribution of neighborhood characteristics to glycemic control (HbA1c; levels of glycosylated hemoglobin over the past 2–3 months) and adherence (measured with a self-report questionnaire) in a sample of late adolescents (high school seniors, ages 17–19) living with Type 1 diabetes.

Research in healthy adolescent samples (Chen et al., 2006) has demonstrated that neighborhood characteristics predict adolescents' health even after considering family socioeconomic factors and subjective social status. Specific to Type 1 diabetes, a recent literature review (Borschuk et al., 2015) revealed that family-level indicators of SES inform diabetes outcomes. Greater household income, more parental education, having health insurance and higher ranked parental occupation were related to better HbA1c values. Knowing the larger context of the neighborhood environment (e.g., poverty level, educational achievement of neighborhood residents, structural aspects) may reveal that when adolescents lack economic and social resources and encounter neighborhood disorder and disadvantage, they experience poorer diabetes management over and above family- and individual-level indicators.

The construct neighborhood disorder and disadvantage (hereafter referred to as neighborhood disorder) (Dulin-Keita et al., 2012), which captures several dimensions of the neighborhood environment, was utilized to understand the contribution of neighborhoods on Type 1 diabetes management. Neighborhood-level data from the 2010 American Community Survey (ACS) were linked to data collected on adolescents' HbA1c levels and adherence behaviors. Following previous work (Dulin-Keita et al., 2012), neighborhood disorder was created by combining five Census-derived neighborhood characteristics. The relationship between neighborhood disorder and diabetes management was examined before and after controlling for family (maternal education) and individual indicators (subjective social status) in order to understand whether neighborhood disorder contributed to indicators of diabetes management over and above traditional individual- and family-level socioeconomic measures. Following results from previous studies on neighborhoods and health indicators (Chen et al., 2006), it was predicted that increased neighborhood disorder would be uniquely associated with higher HbA1c levels and poorer adherence.

Methods

Research Design

High school seniors with Type 1 diabetes were recruited from outpatient pediatric clinics either in-person or over the phone. Of the qualifying 507 individuals approached, 301 (59%) initially agreed to participate, and 247 were subsequently enrolled. Adolescents were eligible if they had been diagnosed with Type 1 diabetes for at least one year, had English as their primary language (required for neurocognitive testing in the larger study), were in their final year of high school, lived with a parent, and had no condition that would prohibit study completion. Adolescents and parent(s) completed an in-person research session where informed consent/assent was obtained, followed by an online survey. Study procedures were approved by Institutional Review Boards at the University of Utah and the University of Texas Southwestern Medical Center. The present study included respondents who completed baseline measures and for whom Census data were available. Due to changes in Census tracts or non-inclusion in the ACS, neighborhood characteristic data were not available for 21 participants. Additionally, two participants were missing maternal education data and 12 subjective social status. Six participants were missing HbA1c data and 14 were missing adherence scores. Missingness was also present in covariates, with 10 participants not reporting ethnicity and or race. Analyses used all available data, and the results include the number of participants in each model.

Predictors

Neighborhood disorder—Participant home addresses were used to determine individuals' Census tract in order to link ACS data. Census tracts are neighborhood areas determined by the U. S. Bureau of Census that are more localized and granular than ZIP code tabulation areas. Census tracts generally encompass population areas between 1,200 and 8,000 people (U.S. Census Bureau, 2012), with the spatial area depending on the density of the population. Although tracts are relatively stable, they may split or merge over time due to changes in population growth or decline.

The ACS Census tract-level data included percent of the population: achieving less than a high school education (10.65 ± 10.82%), under 18 who are living in poverty (14.30 ± 13.67%), unemployed (7.12 ± 3.72%), receiving public assistance (1.60 ± 1.50%), and the percent of households that were vacant (6.62 ± 6.41%). These data were selected to represent the SES of the neighborhood population and the physical environment. *Z* scores were computed for each individual ACS item and were summed to create the neighborhood disorder composite (α =. 75). Higher neighborhood disorder scores indicated neighborhoods with greater disadvantage compared to other neighborhoods in the sample (range −5.33 to 18.94).

Maternal education—Family SES was obtained from online surveys completed by adolescents and their mothers. Mothers reported the highest level of education they achieved from *Some high school or less* to *Professional degree*. For study analyses, this variable was categorized as 0 = less than college and 1 = college or more education.

Subjective social status—Adolescents' subjective social status was obtained using a version of the MacArthur self-anchoring scale, which has been shown to reflect traditional SES measures (Adler & Stewart, 2007). Adolescents were given a picture of a numbered 10-rung ladder and asked to indicate on which rung they thought they stood at that time relative to others in their community. Higher rungs indicated higher social standing (see Goodman et al (2001) for work with adolescent samples).

Covariates—Each model included control variables for test site (0 = Utah, 1 = Texas), insulin pump status (0 = no pump, 1 = pump), diagnosis duration (grand-mean centered), gender (0 = female, 1 = male), ethnicity (0 = non-Hispanic, 1 = Hispanic), and race (0 = White, 1 = Other race).

Outcomes

Glycemic control—Glycated hemoglobin (HbA1c) was indexed from HbA1c assay kits obtained from and processed by CoreMedica Laboratories. Blood samples were collected during the research session and mailed to CoreMedica Laboratories for processing.

Adherence—Adolescents reported on their adherence behaviors in an online survey using the Diabetes Behavior Rating Scale (DBRS; Iannotti et al., 2006), a 37-item measure assessing diabetes management behaviors and problem solving. Higher scores indicated better adherence behaviors. The scale had acceptable reliability (α = .84) and has been shown to be moderately and negatively correlated with HbA1c (Iannotti et al., 2006).

Results

Characteristics of 211 adolescents in the analytic sample are as follows: 60.2% female; 14.7% Hispanic, 85.3% White, 6.2% Black, 2.8% Native American, 1.9% Asian, 1% Native Hawaiian/Pacific Islander, and 2.8% other or multiple race; age 17.8 ± 0.4 years; diabetes duration 7.3 ± 3.9 years; 43.6% using insulin pump.

On average, adolescents' HbA1c was 67 mmol/mol (8.3% ± 1.6), which is above ADA age-specific recommendations (Chiang, Kirkman, Laffel, & Peters, 2014), but they reported following adherence behaviors usually as recommended (0.61. ± 0.12). More mothers reported achieving less than a college education (58.9%) than college or more. Average neighborhood disorder was 0.02 ± 3.59 (median = −0.99, range = −5.30–18.90). Adolescents ranked their subjective social status just above the midpoint (5.52 ± 1.78). Multiple regression analyses revealed that higher neighborhood disorder was significantly associated with higher HbA1c, and that this relationship remained significant when maternal education was included in the model (Table 1). Subjective social status was not significantly associated with HbA1c, though once included in the model, neighborhood disorder was no longer associated with HbA1c. None of the target predictors (neighborhood disorder, maternal education, subjective social status) were significantly associated with adherence.

Discussion

These results suggest that adolescents with Type 1 diabetes who live in disordered neighborhoods are at higher risk for poorer glycemic control. Notably, this association between neighborhood disorder and HbA1c was significant when taking into account maternal education, an important indicator of family SES. Subjective social status was not a significant predictor of HbA1c, though neighborhood disorder became nonsignificant once it was included in the model. Adherence behaviors were not significantly associated with neighborhood disorder, suggesting that the pathway between neighborhood disorder and diabetes management may be physiological rather than behavioral. Residing in a less advantaged neighborhood may contribute to the experience of chronic stress, which may affect HbA1c through physiological pathways.

Exposure to stressors inherent within lower-income neighborhoods is associated with poorer health outcomes in youth (Evans, 2004; Steptoe et al., 2001). Adolescence is a risky period for diabetes management in general (Miller et al., 2015; Wang, Wiebe, & White, 2011), but youth residing in impoverished neighborhoods may be exposed to more stressors, increasing risk for poor glycemic control (Coulon et al., 2016; Clarke, Daneman, Curtis, & Mahmud, 2017). Further, living in a lower socioeconomic neighborhood may undermine parents' ability to be caring and supportive to their child's illness (Drew et al., 2011), possibly by reducing the effectiveness and availability of social support (Ceballo & McLoyd, 2002; Heymann, Earle, & Egleston, 1996).

Limitations

These findings should be interpreted in the context of several limitations. The study sample was predominantly White and included only late adolescents. These results may not generalize to individuals with Type 1 diabetes of other ethnic backgrounds or age groups. It is also possible the results were biased by a somewhat low recruitment rate and exclusive use of a self-report measure of adherence. The study also did not examine the role of perceived stress that could be related to neighborhood disorder. The measure of neighborhood disorder is not exhaustive and excluded other important social and physical indicators of neighborhood-level SES (e.g., access to greenspace and healthy, affordable food choices) (Clarke, Daneman, Curtis, & Mahmud, 2017). It was not possible to determine whether the nonsignificant effects of neighborhood disorder after subjective social status was included in the model were related to the overlap between this measure and neighborhood disorder or to the reduced sample size for this model (due to missing subjective social status data). Additional work comparing the predictive value of other family- and individual-level socioeconomic indicators in addition to neighborhood disorder is needed. Future work should also replicate and extend these findings to further understand the mechanisms driving the neighborhood-HbA1c association more fully.

Conclusions

Despite these limitations, results of the current study highlight the importance of understanding the clinical management of Type 1 diabetes during adolescence in the broader social context. Although how neighborhood disorder confers risk is unknown, it is likely to reflect complex processes across multiple systems (i.e., individual, family, school, medical). Interventions that not only promote individual and family resources, but also community-level resources that enable individuals and families to interface with these broader systems will likely be necessary to address the needs of youth residing in disordered neighborhoods. Several promising multi-system interventions have been developed for youth with poorly managed Type 1 diabetes (Harris et al., 2014), including those living in disadvantaged urban environments (Ellis et al., 2007) that may readily be adapted for youth living in disordered neighborhoods.

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- Socioeconomic status has implications for late adolescents' diabetes management.
- Previous work has focused on family factors (e.g., parental education).
- This study examined neighborhood disorder-diabetes management associations.
- Greater neighborhood disorder was associated with poorer glycemic control.
- Both family and neighborhood SES are related to adolescent diabetes management.

Table 1

Neighborhood, Individual, and Family Indicators of Socioeconomic Status Predicting HbA1c and Adherence

	HbA1c[a]				Adherence			
Model and predictor	***B***	**β**	***SE***	***p***	***B***	**β**	***SE***	***p***
Model 1								
Site	0.324	0.099	0.227	.15	−0.057	−0.230	0.018	< .01
Pump status	−0.709	−0.216	0.229	< .01	0.004	0.015	0.018	.84
Diagnosis duration	0.060	0.142	0.028	.03	−0.002	−0.048	0.002	.50
Gender	0.440	0.132	0.220	.05	−0.013	−0.051	0.018	.47
Ethnicity	0.469	0.101	0.313	.14	−0.017	−0.050	0.025	.49
Race	0.298	0.065	0.317	.35	−0.017	−0.049	0.025	.50
Neighborhood disorder	0.082	0.179	0.032	.01	−0.002	−0.044	0.003	.55
Intercept	8.132	—	0.214	< .001	0.646	0.000	0.017	< .001
	R^2 = .14; *n*=211.				R^2 = .05; *n*=207.			
Model 2								
Site	0.162	0.050	0.231	.48	−0.055	−0.224	0.019	< .01
Pump status	−0.712	−0.217	0.224	< .01	0.004	0.015	0.018	.84
Diagnosis duration	0.057	0.134	0.027	.04	−0.002	−0.051	0.002	.48
Gender	0.539	0.162	0.219	.01	−0.015	−0.060	0.018	.41
Ethnicity	0.254	0.055	0.317	.42	−0.010	−0.029	0.026	.70
Race	0.188	0.040	0.314	.55	−0.012	−0.034	0.025	.64
Mother’s education	−0.684	−0.206	0.233	< .01	0.010	0.040	0.019	.60
Neighborhood disorder	0.081	0.174	0.032	.01	−0.002	−0.044	0.003	.55
Intercept	8.516	—	0.242	< .001	0.641	0.000	0.020	< .001
	R^2 = .19; *n*=209.				R^2 = .06; *n*=205			
Model 3								
Site	0.118	0.036	0.237	.62	−0.051	−0.211	0.019	< .01
Pump status	−0.657	−0.202	0.227	< .01	0.000	0.002	0.018	.98
Diagnosis duration	0.060	0.144	0.028	.03	−0.002	−0.052	0.002	.47
Gender	0.542	0.164	0.224	.02	−0.010	−0.039	0.018	.59
Ethnicity	0.251	0.054	0.325	.44	−0.000	−0.000	0.027	.99

Model and predictor	HbA1c[a]				Adherence			
	B	**β**	***SE***	***p***	***B***	**β**	***SE***	***p***
Race	0.300	0.066	0.321	.35	−0.022	−0.065	0.026	.39
Mother’s education	−0.708	−0.215	0.239	< .01	0.007	0.030	0.019	.70
Subjective social status	−0.066	−0.073	0.062	.28	0.005	0.075	0.005	.30
Neighborhood disorder	0.062	0.131	0.034	.07	0.000	0.007	0.003	.93
Intercept	8.492	—	0.244	< .001	0.641	—	0.020	< .001
	R^2 = .18; *n*=203				R^2 = .06; *n*=201			

Note. Site: 0 = Texas, 1 = Utah. Pump status: 0 = not on pump, 1 = on pump. Mother’s education: 0 = less than college, 1 = college or more. Gender: 0 = female, 1 = male. Ethnicity: 0 = non-Hispanic, 1 = Hispanic. Race: 0 = White, 1 = Other race. All other predictors were grand-mean centered.

[a] HbA1c is a measure of glycemic control, with higher values indicating possible problematic diabetes management.