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The Relationship Between Neighborhood Disadvantage and Kidney Disease Progression in the CKiD Cohort

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Abstract

Rationale & Objective: To examine the relationship between neighborhood poverty and deprivation, chronic kidney disease (CKD) comorbidities, and disease progression in children with CKD.

Study Design: Observational cohort study.

Setting & Participants: Children with mild to moderate CKD enrolled in the CKiD study with available United States Census data.

Exposure: Neighborhood poverty and neighborhood disadvantage.

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Outcome(s): Binary outcomes of short stature, obesity, hypertension, healthcare utilization for cross-sectional analysis; progression to end stage kidney disease (ESKD), and mode of first kidney replacement therapy (KRT) for time-to-event analysis.

Analytical Approach: Cross-sectional analysis of health characteristics at time of first census data collection using logistic regression to estimate odds ratios. Risk for progression analyzed using a Cox proportional hazard model. Multivariable models adjusted for race, ethnicity, sex, and family income.

Results: There was strong agreement between family and neighborhood socioeconomic characteristics. Risk for short stature, hospitalization, and emergency department (ED) use were significantly associated with lower neighborhood income. After controlling for race, ethnicity, sex, and family income, odds of hospitalization (OR 1.71, 95% CI 1.08, 2.71) and ED (OR 1.56, 95% CI 1.02, 2.40) use remained higher for those with lower neighborhood income. The hazard ratio of reaching ESKD for participants living in lower income neighborhoods was significantly increased in the unadjusted model only (1.38, 95% CI: 1.02, 1.87). Likelihood of undergoing a preemptive transplant was decreased with lower neighborhood income (OR 0.47, 95% CI 0.24, 0.96) and higher neighborhood deprivation (OR 0.31, 95% CI 0.10, 0.97), but these associations did not persist after controlling for participant characteristics.

Limitations: Limited generalization, as only those with consistent longitudinal nephrology care were studied

Conclusions: Neighborhood-level SES was associated with poorer health characteristics and CKD progression in univariable analysis. However, the relationships were attenuated after accounting for participant-level factors including race. A persistent association of neighborhood poverty with hospitalizations and ED suggests an independent effect of SES on healthcare utilization the causes for which deserve additional study.

Plain Language Summary

Neighborhood Disadvantage and Outcomes in Children with Chronic Kidney Disease (CKD)

Neighborhood poverty is associated with adverse health outcomes in children, but the specific effects on the health of children with CKD have not been studied. We used data from participants enrolled in the Chronic Kidney Disease in Children (CKiD) study linked to U.S. Census data to explore the association between neighborhood poverty and health characteristics in this population. Children living in areas with the lowest neighborhood income were more likely to be hospitalized and more likely to visit the emergency department for care than children living in higher income neighborhoods, even after accounting for the participants' race and family income. These markers of socioeconomic status were not associated with kidney disease progression. These findings may reflect barriers to healthcare in lower income neighborhoods.

Keywords

CKD; poverty; neighborhood; deprivation; progression; income; hospitalization

Background and Significance

All children with CKD are at high risk for progression to end stage kidney disease (ESKD), and specific demographic and socioeconomic factors have been shown to modify this risk.[1,2] There is evidence that the well-described racial, ethnic, and socioeconomic disparities in outcomes found in the adult CKD population also extend to children with CKD. Black children with CKD have been shown to be more likely to experience faster disease progression, earlier initiation of kidney replacement therapy and were more likely to initiate dialysis rather than receive a kidney transplant.[3,4,5,6] Additionally, White children were more likely than Black children to have undergone a transplant within 2 years of dialysis initiation (70% and 44% respectively).[3] Children from lower income households are also more likely to develop ESKD and less likely to be listed for transplant after initiation of dialysis.[3]

The Chronic Kidney Disease in Children (CKiD) Study is an ongoing multicenter, prospective cohort study examining the natural and treated history of pediatric CKD and its relationship with cardiovascular health, growth and neurocognitive function. The CKiD study collects individual and neighborhood-level socioeconomic data from participants, including census block group (CBG) data. A previous CKiD paper investigating individual-level socioeconomic status (SES) indicators and disease characteristics found that lower household income was associated with Black race, low birth weight, and a higher prevalence of comorbidities including anemia and hypertension.[7] Additionally, children in households with higher income demonstrated reduced height deficit over time, while those in lower income homes saw a worsening height z-score. Interestingly, household income was not associated with risk for CKD progression in this analysis. A competing risks analysis of ESKD (defined here as dialysis initiation or a GFR less than 15 ml/min/1.73m^2) versus preemptive transplant found that children from higher-income households were at lower risk for progression to ESKD, particularly within the early years of study follow-up.[8]

Neighborhood-level SES measures have also been associated with health outcomes in children, including increased likelihood of obesity in adolescents and improved survival in children with hypoplastic left heart syndrome.[9, 10] While studies often focus on specific factors such as neighborhood income, this may provide a limited picture of the overall environment. The Area Deprivation Index (ADI) is a composite measure of 17 census markers that encompass neighborhood poverty, education, employment, and housing, the methodology of which was described by Kind, et al.[11] , and has been associated with health outcomes.[12, 13, 14, 15]

The ADI is available by both zip code and census units. Census block groups are the smallest census unit with available sociodemographic data and include 1,000 people on average. They provide a more exact assessment of neighborhood than zip code because census designations are based on homogeneous population groups rather than geography.[16] Census boundaries are also used for the allocation of federal funds for programs including the Supplemental Nutrition Assistance Program, Head Start, and housing services.[17]

Limited research exists on the effects of neighborhood SES on pediatric CKD and what is published primarily focuses on ESKD. Amaral & Patzer[18] reported that lower neighborhood SES was associated with racial and ethnic disparities in pediatric transplant wait listing and prevalence of living organ donation and that this disparity was more evident among emerging adults (18 to 20 years). Similarly, the disparity between Blacks and Whites for kidney transplant waiting times increased as neighborhood poverty increased.[19] Another analysis demonstrated that racial differences in mortality for adolescent dialysis patients was attenuated by higher neighborhood income.[20] A study in France using the European Deprivation Index, a measure similar to ADI, found higher prevalence of ESKD in the most deprived areas as well as poorer graft survival rates post-transplant.[21] The purpose of the current analysis was to compare neighborhood-level and individual-level SES factors and to examine their relationship to neighborhood disadvantage and disease progression, co-morbidities, and healthcare utilization in a representative cohort of children with pediatric CKD.

Methods

Study Population and Design

CKiD is a multicenter observational prospective cohort study of children with CKD recruited from 59 centers in North America. The initial CKiD study design and methods have been described previously.[22] The CKiD study enrolled children age 1 to 16 with mild to moderate CKD (estimated glomerular filtration rate (eGFR) < 90 ml/min/1.73m^2 at time of study entry). Between 2005 and 2014, 891 participants completed at least one study visit. Annual visits included physical exam, neurocognitive and cardiovascular tests, specimen collection and laboratory tests, and self-reported forms addressing demographics, medical and social history, medications, and quality of life. The study protocol followed the Declaration of Helsinki and was approved by the institutional review board at each participating site. Informed assent/consent was obtained from each participant and/or parent or guardian. Measures of neighborhood SES were taken from the United States Census and matched to CKiD participants by their Federal Informational Processing Standards code at the census block group (CBG) level, which was coded by site coordinators using the census.gov website. CBG data was collected starting in 2009, and 578 CKiD participants from the US had available census data for inclusion in this analysis. The majority (85%) were matched to 2000 Census data while the remaining 15% were linked to the 2010 Census. ADI was matched to 559 (97%) of these records. Data used in this analysis is cross-sectional and taken from the first study visit with available census data except for a longitudinal outcome, progression to ESKD.

Measurements

Patient data—Patient demographics and family-level socioeconomic measures were parental- or self-reported. Race and ethnicity have been categorized as Black (including mixed race) or non-Black and Hispanic or non-Hispanic. Annual family income was reported in categories and classified as higher income (≥ $36,000 per year) and lower income (<$36,000). Insurance type was based on self-report and categorized as no insurance (none), any public, and private.

Underlying diagnosis of CKD was categorized as either glomerular (G) or non-glomerular (non-G) based on a pre-determined, coded list.[22] Height and weight were collected using a standardized process and z-score for height and body mass index (BMI) were calculated based on age and gender.[23] Age- and sex-specific height and BMI SD scores (*z*-scores) were calculated using the United States (US) Centers for Disease Control and Prevention (CDC) growth charts of normative data.[24] Short stature was defined as a height *z*-score below −1.88 and obesity as a BMI z-score above 1.65. Hospitalizations and emergency department (ED) visits within the past year were reported by caregivers/patients and then dichotomized into none or any occurrence. Hypertension was defined as either a measured manual systolic blood pressure at or above the 95th percentile for age, sex, and race or a self-reported diagnosis and the use of at least one anti-hypertensive medication. Time to ESKD was calculated as time between the study visit used in the analysis and the onset of kidney replacement therapy (KRT, defined as either preemptive transplant or initiation of dialysis) or 50% reduction in GFR based on the 2012 eGFR estimating equation.[25]

Neighborhood data—Median neighborhood income was dichotomized between those in the lowest quartile neighborhoods (median neighborhood income < $32,721) and those in the top three. Neighborhood deprivation was categorized as either high deprivation or lower deprivation using the ADI cut-point of ≥ 113.45 previously established by Kind, et al.[11] This cut-point reflects the 15% most disadvantaged neighborhoods in their sample of over 250,000 people. Percent Black and percent Hispanic were calculated by dividing the number of neighborhood residents who matched the corresponding demographics by the total neighborhood population.

Statistical Analysis

To investigate the face validity of the data and to describe how neighborhood-level characteristics related to participant-level characteristics, we used Wilcoxon rank-sum tests to compare neighborhood-level metrics (median income, ADI, percentage Black, and percentage Hispanic) by participant-reported dichotomous groupings (household income, race, and ethnicity). Logistic regression was used to estimate odds ratios of participant characteristics (dependent variables of short stature, obesity, hypertension, hospitalizations in the last year, ED visits in the last year, and preemptive transplant) based on neighborhood-level risk factors (independent variables: lowest quartile median neighborhood income and high ADI) in both univariate models and models adjusted for race, ethnicity, sex, and family income, as these are factors that may be associated with clinical outcomes. Sex was included as a variable in the multivariate model examining risk for CKD progression specifically as male sex has been associated with faster time to progression of CKD in a previous CKiD analysis.[22] Time-to-ESKD analysis was performed using a Cox proportional hazard model, and the validity of the conditions of the Cox model was checked using a test of proportional hazards assumption. All statistical analyses were conducted using Stata Version 14 (College Station, TX: StataCorp LLC). Statistical significance was defined as $p < 0.05$.

Results

Participant Characteristics

Demographics—Table 1 describes the demographic and clinical characteristics of the study cohort, including disease characteristics and health care utilization, at the time of first census data collection. The median age was 11.9 years and 60% were male. The cohort was 26% Black and 17% Hispanic. About 45% of participants reported less than $36,000 annual family income. The cohort demonstrated minimal geographic mobility; the large majority (92.3%) lived within the same ZIP code for more than 1 year. Very few participants (2%) were uninsured and nearly half (47%) had public insurance. Short stature was present in 13% of participants and nearly 20% were obese. Nearly half of participants (47%) had hypertension. In the year preceding the visit, 28% had been hospitalized while 42% had visited an ED at least once. Median eGFR was 51 ml/min/1.73m^2, corresponding to Stage 3 CKD. Of the participants included in this analysis, 32% progressed to KRT during follow-up. Thirty-seven percent of those patients received a preemptive kidney transplant as the initial mode of KRT.

Neighborhood characteristics

Table 2 describes the neighborhood characteristics of participant census blocks including median household income, which was similar to the national median income ($42,148) in 2000,[26] the year from which most data was drawn. Neighborhood residents were majority non-Black, non-Hispanic.

Association between Individual and Neighborhood Characteristics

Table 3 presents the statistically significant relationship between participant and neighborhood characteristics. Median neighborhood income was higher for participants whose family income was above $36,000. Neighborhood income was also higher for participants who were non-Black and non-Hispanic. ADI was higher for lower income families and Black participants, with no significant difference for Hispanic and non-Hispanic participants. The median percentage of neighborhood population that was Black was higher for Black participants than non-Black participants. Similarly, the median percentage of Hispanic neighborhood population that was Hispanic was higher for Hispanic participants than non-Hispanic. This illustrates the high level of agreement between participant and neighborhood demographics in the cohort, suggesting that CKiD participants live in neighborhoods that are relatively homogeneous in terms of race/ethnicity/socioeconomic status. There was also a statistically significantly higher percentage of Black neighborhood residents among Hispanic participants. However, the neighborhood percent Hispanic was similar for Black and non-Black participants.

Association between Neighborhood Economic Factors and Participant Clinical Characteristics

Table 4 shows the associations between neighborhood-level risk factors and participant clinical characteristics and healthcare utilization. Participants in the lowest income neighborhoods were more likely to be short than those in the higher neighborhood

income quartiles (OR 1.77, 95% CI 1.06, 2.96). They were also more likely to have been hospitalized and to have been to the ED in the past year. Preemptive kidney transplant as treatment for ESKD was significantly less likely for participants residing in the lowest income quartile neighborhoods (OR 0.47, 95% CI 0.24, 0.96). After adjustment for individual family income, sex, and race/ethnicity, lowest neighborhood income remained significantly associated with only hospitalizations and ED visits (OR 1.71, 95% CI 1.08, 2.71 and 1.56, 95% CI,1.02, 2.40, respectively). High ADI was not significantly associated with any health characteristics in the multivariable model.

Association of Neighborhood Factors with Progression to ESKD

In univariate analysis, the hazard ratio for reaching ESKD for participants living in the lowest neighborhood median income quartile was significantly increased by nearly 40%. However, this relationship was not significant after adjustment for participant race, ethnicity, sex, and family income. ADI was not significantly associated with hazard of progression to ESKD in either the univariate or adjusted analyses. (Table 5)

Discussion

In this analysis we examined the influence of neighborhood-level factors on health and disease progression in children with CKD, demonstrating a strong relationship between individual participant income, race, and ethnicity and the characteristics of their neighborhoods, and this also provided face validity to the data. Children living in the lowest income neighborhoods demonstrated increased urgent healthcare utilization in the form of emergency department visits and hospitalizations, even after adjustment for individual race, ethnicity, and family income, suggesting that neighborhood characteristics contribute independently to health outcomes in children with CKD. Complications of CKD, including those related to cardiovascular and infectious complications, may lead to ED visits or hospitalization for affected patients.[6] Unplanned hospital admissions are disruptive to patients and their families, and may be costly due to both medical bills and indirect expenses such as missed work.

Our results are consistent with those in other pediatric chronic diseases. Children with asthma are more likely to utilize ED visits and hospitalizations if they reside in economically disadvantaged communities, an association that has been shown to be independent of race.[27] Risk factors for unplanned hospital admissions may include barriers to disease control (e.g. access to antihypertensive medications) or limited outpatient medical resources in the participant's local area, requiring emergent or inpatient care for medical management. Physical, geographic barriers to accessing routine care such as lack of reliable transportation may be higher in lower income neighborhoods, discouraging efficient utilization of follow-up visits and contributing to poor medication adherence. The point estimates for odds of hospitalization or ED visits by median neighborhood income did adjust in opposite directions in the models adjusted for individual-level factors including race and family income (Table 4); the odds of ED visit was slightly attenuated and the odds for hospitalization slightly increased. This may indicate that the individual factors included in

the adjusted model had an additive effect with neighborhood income in terms of risk for hospitalization.

Short stature is prevalent in children with CKD and is associated with decreased quality of life.[28] We found that short stature was associated with low neighborhood income in univariate analysis, but after adjustment for individual characteristics including race and family income the association was not significant. The analysis did not control for use of growth hormone, but a previous CKiD analysis showed that only around half of those who qualify based on growth failure receive this therapy.[29] Future research should examine how neighborhood-level factors affect access to growth hormone in this population.

We examined the associations between neighborhood income and both obesity and hypertension. Increased BMI was previously associated with higher HDL cholesterol and triglycerides, elevated systolic blood pressure, and greater left ventricular mass index in children in the CKiD cohort.[30] Obesity was also associated with poor outcomes for pediatric kidney transplant recipients, including a higher likelihood of graft failure and acute rejection.[31] Although nearly 20% of the children included in this analysis were obese, low neighborhood income was not significantly associated with risk for obesity. Similarly, although hypertension is strongly associated with progression of CKD in pediatric patients, we found that hypertension was not associated with any neighborhood-level factors. This may indicate that disease-specific factors are more closely related to hypertension risk in children in CKiD than neighborhood factors such as access to healthy food and space to foster physical activity, which likely influence risk for hypertension in otherwise healthy adults. Alternatively, we acknowledge that the limited neighborhood factors and summary scores used in this analysis may not have fully captured the environmental stressors related to CKD comorbidities and severity.

We also examined the association between neighborhood factors and CKD progression and renal transplantation. Although lower neighborhood income was associated with a higher likelihood of progression in the univariate model, after adjustment for individual-level factors the association was not significant, suggesting that the local environment (at least the characteristics captured in this analysis) was not a dominant risk factor for CKD progression in this population.

Preemptive renal transplant is the preferred method of KRT for patients reaching ESKD,[32] and we have previously shown that participants in CKiD are more likely to receive a preemptive transplant than pediatric CKD patients in general (39% versus 19.4% of national incident pediatric KRT in 2014).[33] In the univariate analyses, residing in a neighborhood with higher disadvantage was associated with a reduced likelihood of preemptive transplant. However, after adjustment for race, sex, ethnicity, and family income, the association was not significant, suggesting that individual-level factors were more associated with the transplant process in children enrolled in CKiD.

There were several limitations to this analysis. Children enrolled in CKiD may not be representative of the entire population of children with CKD, as enrollment reflects high engagement with subspecialty pediatric nephrology care, English or Spanish as their

primary language, and the ability to make time for participation in annual study visits. Thus, the relationship between neighborhood deprivation and clinical outcomes may be attenuated in CKiD participants who have a high level of engagement with longitudinal care. Although it's notable that even among this cohort of patients, urgent healthcare utilization is associated with low neighborhood income, we did not have access to data on the clinical indications for urgent health visits or hospitalizations, and so could not examine the specific reasons for these visits. There are likely other neighborhood level factors, such as presence of food banks or community social workers, that influence health outcomes but we were unable to examine as part of this analysis due to lack of available data. We also analyzed census data from a single, early study timepoint, and so were unable to assess how changes in neighborhood-level factors were associated with outcomes over time. Additionally, while most of the cohort were matched to 2000 census data, 15% of the cohort were matched to 2010 data and there may be limitations on the comparability of this data. Finally, we did not have access to data regarding patients who had experienced a geographic move in the year prior to data collection and so could not assess impact of changes in neighborhood-level economic factors on outcomes.

This analysis points towards several avenues of future research. An extension of this study into a broader cohort of pediatric CKD patients from additional sources of care may reduce the limitations discussed above. Collection of neighborhood-level data at time of pregnancy and birth may lead to a greater understanding of their effect on fetal renal development, prematurity and low birth weight, which we did not assess in this analysis. It may also expand knowledge of how early childhood neighborhood-level factors affect longer-term CKD outcomes. An examination of the influence of neighborhood factors on health-related quality of life, collected in the CKiD cohort, would also be informative.

In summary, this analysis demonstrated that although neighborhood SES was associated with health characteristics in the CKiD cohort, the associations were attenuated after accounting for race and individual family income. Institutions may expand this knowledge through health disparity training for providers toward the goal of optimizing care for each individual patient. Neighborhood income does have a significant impact on participant healthcare utilization, with higher rates of hospitalization and ED usage in poorer communities, demonstrating that healthcare services may not be reaching all those who need it, even in this population of patients who are well-connected to subspecialty care. On a policy level, it is important to note that insurance alone is not enough to reduce the effects of neighborhood poverty on health, as this population is almost fully insured. Interventions to increase the density of first-line providers, reduce physical and geographic barriers to accessing routine health care, and promote health literacy and self-management skills may be approaches to alleviate the burden of urgent health care utilization in this population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Individual demographic and clinical characteristics of the study cohort at the time of first census data collection (n=578)

Individual Characteristic:	Median (IQR) or % (n)
Age, years	11.9 (8.0, 14.9)
Male	59.9% (346)
Black	26.1% (151)
Hispanic/Latino	16.6% (95)
Annual Family Income ≤ $36,000	44.6% (251)
Current Zip Code > 1 Year	92.3% (179)
Insurance Status	
None	2.0% (11)
Public	47.4% (256)
Short stature*	13.3% (77)
Obese$^{\alpha}$	18.4% (102)
Hypertension$^{\beta}$	47.2% (268)
Hospitalized in Last Year	28.1% (156)
ED Visit in Last Year	41.6% (229)
eGFR, ml/min/1.73m^2	51.0 (37.6, 63.4)
Renal Replacement Therapy (n=184)	
Dialysis	63.0% (116)
Transplant	37.0% (68)

*height z-score < −1.88,

$^{\alpha}$body mass index z-score > 1.65.

$^{\beta}$systolic blood pressure ≥95th percentile or a self-report diagnosis and at least one anti-hypertensive medication,

eGFR – estimated glomerular filtration rate.

Table 2.

Summary of neighborhood characteristics for all participants(n=578)

Neighborhood Characteristic	Median (IQR)
Median Household Income	$43,056.50 ($32,726, $59,100)
Area Deprivation Index	103.33 (93.51, 109.40)
Census Block Group Population: Percent Black	2.46 (0.69, 16.72)
Census Block Group Population: Percent Hispanic	2.34 (1.08, 8.09)

Table 3.

Comparison of participant and neighborhood socioeconomic indicators for participants enrolled in CKiD. (n=578)

	Median (IQR)					
	Participant Family Income		**Participant Race**		**Participant Ethnicity**	
	≤$36,000 (n=251)	**> $36,000 (n=327)**	**Not Black (n=427)**	**Black (n=151)**	**Not Hispanic (n=483)**	**Hispanic (n=95)**
Neighborhood Income	$35,731 ($28,451, $46,350)	$51,404 ($40,072, $69,412)	$46,282 ($35,567, $62,516)	$35,207 ($26,798, $46,633)	$44,841 ($33,076, $61,447)	$37,039 ($28,056, $51,148)
	p < 0.001		**p < 0.001**		**p < 0.001**	
Neighborhood ADI	107.71 (101.16, 112.60)	97.97 (88.56, 106.28)	100.44 (90.64, 107.91)	108.19 (102.92, 113.54)	103.18 (92.7, 109.15)	104.32 (95.26, 111.96)
	p < 0.001		**p < 0.001**		p = 0.10	
Neighborhood % Black	5.87 (0.8, 38.4)	1.80 (0.6, 5.6)	1.60 (0.48, 4.6)	37.23 (9.1, 73.6)	2.20 (0.56, 16.1)	3.40 (1.2, 20.3)
	p < 0.001		**p < 0.001**		**p = 0.05**	
Neighborhood % Hispanic	2.75 (1.2, 21.4)	1.99 (1.0, 5.1)	2.27 (1.1, 8.1)	2.54 (1.1, 8.2)	1.88 (0.97, 4.6)	29.0 (9.1, 55.4)
	p = 0.001		p = 0.81		**p < 0.001**	

P-values are based on the Wilcoxon rank-sum test

Table 4.

Association between neighborhood-level risk factors and CKD co-morbidities and healthcare utilization

Health Characteristic Outcome	Odds Ratio (95% CI) and p-value			
	Median Neighborhood Income < $32,721 per year (n=578)		Area Deprivation Index ≥ 113.45 (n=559)	
	Unadjusted	Adjusted**	Unadjusted	Adjusted**
Short Stature *	1.77 (1.06, 2.96) **p=0.03**	1.34 (0.75, 2.40) p= 0.32	1.67 (0.86, 3.23) p= 0.13	1.38 (0.65, 2.92) p= 0.40
Obese α	1.14 (0.70, 1.85) p= 0.59	0.74 (0.44, 1.28) p= 0.28	1.10 (0.57, 2.10) p= 0.78	0.66 (0.31, 1.34) p= 0.24
Hypertension β	1.40 (0.96, 2.05) p= 0.08	1.43 (0.94, 2.19) p= 0.10	1.20 (0.72, 1.99) p= 0.49	1.03 (0.59, 1.81) p= 0.92
Hospitalized in Last Year	1.55 (1.03, 2.35) **p= 0.04**	1.71 (1.08, 2.71) **p= 0.02**	1.04 (0.59, 1.84) p= 0.89	1.15 (0.62, 2.14) p= 0.66
Emergency Room Visit in Last Year	1.71 (1.16, 2.52) **p= 0.01**	1.56 (1.02, 2.40) **p= 0.04**	1.24 (0.74, 2.07) p= 0.42	1.00 (0.57, 1.78) p= 0.99
Preemptive Transplant	0.47 (0.24,0.96) **p= 0.04**	0.81 (0.37, 1.77) p= 0.59	0.31 (0.10, 0.97) **p= 0.04**	0.51 (0.15, 1.72) p= 0.28

* height z-score < −1.88,

α body mass index z-score > 1.65.

β systolic blood pressure ≥95th percentile or a self-report diagnosis and at least one anti-hypertensive medication

** Model includes participant race, ethnicity, sex, and family income category

Table 5.

Association between neighborhood-level risk factors and CKD progression

Health Characteristic Outcome	Hazard Ratio (95% CI) and p-value			
	Predictor: Median Neighborhood Income < $32,721 per year (n=578)		Predictor: Area Deprivation Index ≥ 113.45 (n=559)	
	Unadjusted	Adjusted**	Unadjusted	Adjusted**
ESKD *	1.38 (1.02, 1.87) **p= 0.04**	1.26 (0.90, 1.77) p=0.18	1.09 (0.72, 1.65) p= 0.69	0.85 (0.52, 1.34) p= 0.38

Cox regression-based test for equality of survival curves

* RRT or halving of eGFR

** Model includes participant race, ethnicity, sex, and family income category