Kidney360

Housing Insecurity and Risk of Adverse Kidney Outcomes

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Abstract

Background Housing insecurity is characterized by high housing costs or unsafe living conditions that prevent self-care and threaten independence. We examined the relationship of housing insecurity and risk of kidney disease.

Methods We used longitudinal data from the Healthy Aging in Neighborhoods of Diversity across the Life Span study (Baltimore, MD). We used multivariable regression to quantify associations between housing insecurity and rapid kidney function decline (loss of >5 ml/min per 1.73 m^2 of eGFR per year) and, among those without kidney disease at baseline, incident reduced kidney function (eGFR <60 ml/min per 1.73 m^2) and incident albuminuria (urine albumin-creatinine ratio [ACR] ≥30 mg/g).

Results Among 1262 participants, mean age was 52 years, 40% were male and 57% were black. A total of 405 (32%) reported housing insecurity. After a median of 3.5 years of follow-up, rapid kidney function decline, incident reduced kidney function, and incident albuminuria occurred in 199 (16%), 64 (5%), and 74 (7%) participants, respectively. Housing insecurity was associated with increased odds of incident albuminuria (unadjusted OR, 2.04; 95% CI, 1.29 to 3.29; adjusted OR, 3.23; 95% CI, 1.90 to 5.50) but not rapid kidney function decline or incident reduced kidney function.

Conclusions In this urban population, housing insecurity was associated with increased risk of subsequent albuminuria. Increased recognition of housing insecurity as a social determinant of kidney disease is needed, and risk-reduction efforts that specifically target populations experiencing housing insecurity should be considered.

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Introduction

Housing insecurity is characterized by high housing costs or unsafe living conditions that prevent general self-care and threaten independence. It is variably defined as having one or more of the following: debilitating housing costs (>30% of monthly income) and living in unsafe or overcrowded housing conditions (1,2). Housing insecurity has been linked to delayed healthcare visits and poor self-reported health status (3). Housing insecurity has also been associated with risk factors for kidney disease, including hypertension (4) and diabetes self-efficacy (5). Poor health behaviors and risk factors for kidney disease may influence incidence of CKD and, in those with kidney disease, lead to kidney function decline. However, an association between housing insecurity and incident kidney disease has not been reported.

The mortgage crisis in the United States that began in 2007 led to the Great Recession, with >9.6 million jobs lost between 2008 and 2010 (6). Housing insecurity increased in 2009 and peaked in 2011, when 30% of United States homeowners and 51% of renters spent >30% of their income on housing (7). The prevalence of housing insecurity has subsequently improved but remains higher than prerecession estimates for renters. Housing insecurity is often concentrated in metropolitan areas, is higher in black and Hispanic households than among non-Hispanic whites, and, on average, those with housing insecurity are left with <$100 per month to spend on healthcare (7).

We aimed to examine the association of housing insecurity and subsequent kidney disease in an urban population during a time period when housing insecurity was pronounced. We hypothesized that individuals living with housing insecurity would be at higher risk for rapid kidney function decline and incident kidney disease.

Materials and Methods

Study Population

We examined data from the National Institute on Aging, Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study. The HANDLS study design has been described in detail (8). Briefly, HANDLS is a population-based cohort study examining the influence and interaction of race and socioeconomic status on the development of cardiovascular

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and cerebrovascular health disparities among minorities and lower socioeconomic status groups (8). The cohort included 3720 black and white community-dwelling individuals between the ages of 30 and 64 who were sampled from 13 neighborhoods (group of contiguous census tracts) in both low and high socioeconomic strata in Baltimore City, Maryland. Participant enrollment took place from August 2004 to November 2008, with a plan for longitudinal follow-up for 20 years with five triennial study visits. Each participant provided written informed consent, and the National Institute of Environmental Health Sciences, National Institutes of Health (NIH) approved the study protocol.

We evaluated the association between housing insecurity at HANDLS visit three (which took place between June 2009 and July 2013) and kidney outcomes at visit four (which took place between September 2013 and September 2017). Individuals were excluded if they did not attend visit three and four (N=1445), were missing data on housing insecurity (N=523), were missing data on kidney function (N=398), or missing covariables of interest (N=98) (Figure 1). Individuals with all levels of kidney function were included in the rapid kidney function decline analysis (N=1262). Persons with prevalent eGFR <60 ml/min per 1.73 m^2 (N=42) and urine albumin-to-creatinine ratio (ACR) ≥30 mg/g (N=142) at visit three were excluded from the incident reduced eGFR (N=1220) and albuminuria analyses (N=1120), respectively. Compared with included participants, those excluded were older (mean [SD] age 53.7 [9.1] years versus 52.2 [8.9]), more likely to be male (48% versus 40%) (P<0.001 for both), and more likely to report annual income below the federal poverty level at enrollment (43% versus 38%; P=0.009).

Measurement of Housing Insecurity

Housing insecurity was measured during visit three using an audio-administered questionnaire with a computer and headphones. Housing insecurity was defined as a negative response to the question, "Are you able to afford a home suitable for you and your family?" This specific question was chosen over other HANDLS housing variables because it had the least amount of missing data (Supplemental Table 1). Those who reported inability to afford a suitable home were more likely to rent than own their home, more likely to report of difficulty making rent or mortgage payments, difficulty paying for home repairs, and were more likely to report sometimes or always living with relatives or friends. The question chosen was 50% sensitive and 78% specific for difficulty paying rent or mortgage, 32% sensitive and 68% specific for mortgage that was foreclosed or notice of foreclosure, 32% sensitive and 68% specific for report of sometimes living with relatives, and 54% sensitive and 68% specific for sometimes living with friends. Traditional measures of housing insecurity, such as rent-to-income ratio and occupants per room, were not available in HANDLS.

Measurement of Outcomes

Fasting blood and random urine samples were obtained during study visit medical assessments. Serum creatinine was measured at Quest Diagnostics Inc. by isotype dilution mass spectrometry (Olympus America Inc., Melville, NY) and standardized to the reference laboratory at the Cleveland Clinic. Urine ACR measures were performed at Quest Diagnostics Inc. using an immunoturbidimetric assay (Kamiya Biomedical Co., Seattle, WA). GFR was estimated using the creatinine-based CKD Epidemiology Collaboration equation (9). Rapid kidney function decline was defined according to the Kidney Disease Improving Global Outcomes guideline (10) as a decline in eGFR of >5 ml/min per 1.73 m^2 per year between visits three and four. Incident reduced eGFR and albuminuria were defined as new eGFR <60 ml/min per 1.73 m^2 and new urine ACR ≥30 mg/g, respectively, at visit four.

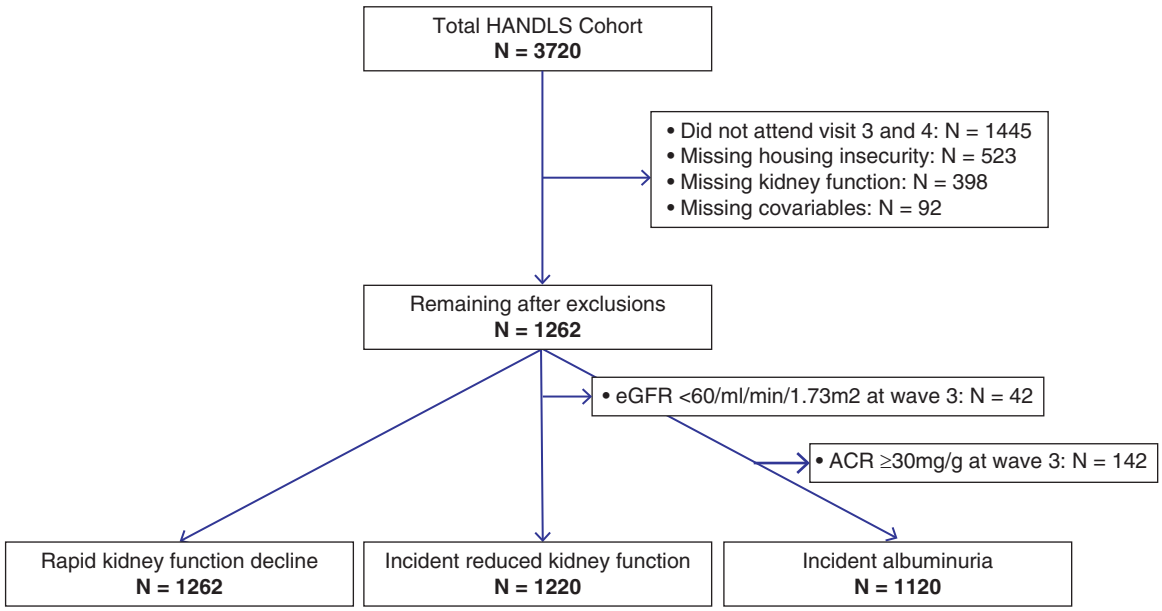

Figure 1. | **HANDLS cohort and study population.** HANDLS, Healthy Aging in Neighborhoods of Diversity across the Life Span; ACR, urine albumin-to-creatinine ratio.

Measurement of Covariables

Sex at birth, self-identified black or white race, household income above or below 125% of the federal poverty level (11), and education level were ascertained at enrollment. All other covariates were ascertained at visit three. Systolic and diastolic BP were defined as the averages between left- and right-arm sitting measurements. Diabetes status was defined as self-report of diabetes, fasting glucose ≥126 mg/dl, prescription for diabetes management, or serum hemoglobin A1c ≥6.5%. Smoking status was defined as self-report of current cigarette use (yes/no). Unemployment status was self-reported (yes/no). Information regarding financial issues was ascertained *via* audio questionnaires. Food insecurity was defined as self-report of having to skip meals in the past 12 months due to insufficient money for food. Inability to afford medical care was defined as self-report of "not having enough money for the kind of medical care [their] family should have." Educational attainment was defined using self-report of having completed high school (yes/no).

Statistical Analyses

We compared baseline characteristics between individuals with and without housing insecurity at visit three using chi-squared test for categoric variables and *t* tests for continuous variables. We used multivariable regression to identify participant characteristics associated with housing insecurity at wave three. Results were used in conjunction with existing literature, likelihood ratio tests for null versus extended models, and Akaike information criterion to determine adjustment models for the main analyses. We tested for collinearity of variables using variance inflation factors. All outcomes were analyzed as dichotomous variables.

For the rapid kidney function decline analysis, we estimated the incidence of rapid kidney function decline at visit four overall and for each housing (insecure and secure) group. We used log binomial regression to estimate the association between housing insecurity and rapid eGFR decline, and Poisson regression with robust estimate of variance when log binomial models failed to converge. We performed four regression models: unadjusted, adjusted for demographics (race, sex, age, and poverty status), additionally adjusted for wave three clinical variables (eGFR, ACR, systolic BP, and diabetes status), and additionally adjusted for financial resource strain (food insecurity, inability to afford medical care, and unemployment).

We estimated the incidence of reduced eGFR and albuminuria at visit four overall and for each housing group. We then used logistic regression to estimate the association between housing insecurity and incident kidney disease adjusting for demographics, clinical variables, and financial resource strain.

We examined potential effect modification by race by including an interaction term for race × housing insecurity for each outcome, given prior studies demonstrating differential associations between socioeconomic status and kidney outcomes by race (11,12). We examined potential effect modification by diabetes status, systolic BP, eGFR, and albuminuria. The interaction term was included in the adjusted models if the *P* for interaction was ≤0.1. We presented outcomes stratified by the effect modifier variable if the *P* for interaction was ≤0.1.

In all analyses, we controlled the possibility of confounding by United States census tract through fixed effects modeling, clustered on neighborhood. All analyses were performed using Stata version 15 (StataCorp, College Station, TX). A *P* value <0.05 was considered statistically significant.

Sensitivity Analyses

To account for HANDLS participants who died between waves three and four, we repeated all analyses using composite outcomes of death or adverse kidney event. To examine the interrelationship of multiple sources of financial strain, we created a financial strain score that included housing insecurity as an overall component of resource burden. The financial strain score ranged from zero to four according to the number of financial resource strain indicators present (housing insecurity, food insecurity, ability to afford medications, and unemployment). For example, individuals with housing insecurity alone or food insecurity alone received a score of one, and those with all four variables received a score of four. We used log binomial and logistic regression to evaluate for associations between the financial strain score and all three outcomes. We defined housing insecurity as self-report of inability to afford a suitable home or difficulty paying rent or mortgage and repeated the analyses. We repeated the rapid eGFR decline analysis using the outcome of 3% decline in eGFR between waves three and four. Finally, to evaluate the effect of the financial recession and unemployment, we limited our study population to individuals who reported employment at wave one and unemployment at wave three.

Results

The study population had a mean (SD) age of 52 (8.9) years; 40% were male and 57% were black. At baseline, 405 (32%) were housing insecure. Compared with those with secure housing, those living with housing insecurity were younger and more likely to be male, of black race, report income <125% of the federal poverty level, smoke, be unemployed, have food insecurity and inability to afford medical care, and were less likely to have a high-school degree ($P<0.01$ for all) (Table 1). Male sex, black race, current use of cigarettes, unemployment, food insecurity, and inability to afford medical care were associated with housing insecurity ($P<0.001$ for all) at baseline in multivariable regression. There was no evidence of collinearity of resource strain variables (variance inflation factor <10 for all).

Participants were followed for a median of 3.5 years. Overall, 199 (16%) participants experienced rapid kidney function decline, with 74 (18%) and 125 (15%) among those with and without housing insecurity, respectively. The median (interquartile range) change in eGFR between waves three and four was −7 (−14.3, −0.6) ml/min per 1.73 m^2 for the entire cohort, and −24.1 (−32.6, −18.3) ml/min per 1.73 m^2 for those with rapid eGFR decline. Housing insecurity was not statistically significantly associated with rapid kidney function decline (unadjusted incidence rate ratio, 1.25; 95% CI, 0.95 to 1.66; adjusted incidence rate ratio, 1.16; 95% CI, 0.88 to 1.52) (Table 2). The relationship between housing insecurity and rapid kidney function

Table 1. Baseline characteristics according to housing insecurity status (wave three)

Variable	No Housing Insecurity (*N*=857)	Housing Insecurity (*N*=405)	*P* Value
Age, mean (SD)	52.7 (9.4)	51.3 (7.8)	0.01
Male sex at birth, *N* (%)	313 (36.5)	191 (47.2)	<0.001
Black race, *N* (%)	463 (54.0)	251 (62.0)	0.01
Annual income <125% federal poverty level, *N* (%)	279 (32.6)	198 (48.9)	<0.001
Unemployed, *N* (%)	337 (39.3)	280 (69.1)	<0.001
Inability to afford medical care, *N* (%)	397 (46.3)	330 (81.5)	<0.001
Food insecurity, *N* (%)	186 (21.7)	204 (50.4)	<0.001
Graduated high school, *N* (%)	630 (75.3)	241 (60.9)	<0.001
eGFR, mean (SD)	95.5 (18.5)	97.4 (19.0)	0.09
ACR, mean (SD)	22.8 (88.9)	25.5 (123.5)	0.66
Systolic BP, mean (SD)	122.2 (16.8)	121.7 (17.2)	0.65
Diabetes, *N* (%)	144 (16.8)	72 (17.8)	0.67
Current smoker, *N* (%)	263 (35.1)	200 (53.5)	<0.001

ACR, albumin-to-creatinine ratio.

decline was not modified by race, diabetes status, systolic BP, eGFR, or ACR (*P* for interaction >0.1 for all).

Overall, 64 (5%) participants developed incident reduced eGFR, with 15 (4%) and 49 (6%) among those with and without housing insecurity, respectively. Housing insecurity was not significantly associated with incident reduced eGFR (unadjusted odds ratio [OR], 0.63; 95% CI, 0.34 to 1.16; adjusted OR, 0.72; 95% CI, 0.36 to 1.43). The relationship between housing insecurity and incident reduced eGFR was not modified by race, diabetes status, systolic BP, or ACR (*P* for interaction >0.1 for all). There was effect modification by eGFR (*P* for interaction 0.01). Those with an eGFR >90 ml/min per 1.73 m^2 had lesser odds of incident reduced eGFR associated with housing insecurity than those with eGFR between 60 and 90 ml/min per 1.73 m^2 (for eGFR >90 ml/min per 1.73 m^2, adjusted OR, 0.23; 95% CI, 0.03 to 1.63; for eGFR between 60 and 90 ml/min per 1.73 m^2, adjusted OR, 0.90; 95% CI, 0.36 to 2.25; Supplemental Table 2).

Overall, 74 (7%) participants developed albuminuria at visit four, with 35 (10%) and 39 (5%) among those with and without housing insecurity, respectively. The median (interquartile range) change in ACR between visits three and four was 0 (−2, 3) mg/g. Housing insecurity was associated with increased risk of albuminuria in the unadjusted and fully adjusted models (unadjusted OR, 2.04; 95% CI, 1.29 to 3.29; fully adjusted OR, 3.23; 95% CI, 1.90 to 5.50). The relationship between housing insecurity and incident albuminuria was not modified by diabetes status, systolic BP, eGFR, or ACR (*P* for interaction >0.1 for all). There was a trend toward effect modification by race for the relationship between housing insecurity and albuminuria (*P* for interaction=0.099; Supplemental Table 3). The odds of incident albuminuria associated with housing insecurity was greater for white than for black participants (among whites, adjusted OR for albuminuria, 1.95; 95% CI, 0.94 to 4.05; among blacks, adjusted OR for albuminuria, 1.27; 95% CI, 0.53 to 3.07).

There were 35 deaths (20 and 15 for the housing insecure and secure participants, respectively) between visits three and four. In the composite outcome analyses, and when compared to our primary analyses, associations were stronger for risk of death or rapid kidney function decline but were null for incident reduced eGFR and ACR (Supplemental Table 4). Findings were similar to our primary analyses when housing insecurity was modeled as a component of overall financial resource strain (Table 3). Risk of albuminuria significantly increased with increasing financial strain score and the association remained significant after adjusting for demographic and clinical variables (unadjusted OR per unit increase in score, 1.43; 95% CI, 1.14 to 1.80; fully adjusted OR, 1.30; 95% CI, 1.00 to 1.68). Findings were similar to our primary analyses when housing insecurity

Table 2. Risk of rapid eGFR decline, incident reduced eGFR, and incident albuminuria associated with housing insecurity

Analysis	Regression Estimate
Rapid eGFR decline (*N*=1262; 199 events), incidence rate ratio (95% CI)	
Model 1	1.25 (0.95 to 1.66)
Model 2	1.24 (0.77 to 1.53)
Model 3	1.24 (0.95 to 1.62)
Model 4	1.16 (0.88 to 1.52)
Incident eGFR <60 ml/min per 1.73 m^2 (*N*=1220; 64 events), odds ratio (95% CI)	
Model 1	0.63 (0.34 to 1.16)
Model 2	0.81 (0.43 to 1.54)
Model 3	0.82 (0.43 to 1.56)
Model 4	0.72 (0.36 to 1.43)
Incident ACR ≥30 mg/g (*N*=1120; 74 events), odds ratio (95% CI)	
Model 1	2.04 (1.29 to 3.29)
Model 2	3.83 (2.19 to 6.71)
Model 3	3.80 (2.21 to 6.52)
Model 4	3.23 (1.90 to 5.50)

Model 1 was unadjusted; model 2 was adjusted for demographics (age, race, interaction with race × housing insecurity, sex at birth, and poverty status); model 3 was adjusted for demographics and clinical variables (eGFR, ACR, systolic BP, and diabetes status); model 4 was adjusted for demographics, clinical variables, and financial resource strain variables (unemployment, food insecurity, ability to afford medical care). CI, confidence interval; ACR, albumin-to-creatinine ratio.

was defined as report of inability to afford a suitable home or difficulty paying rent or mortgage (Supplemental Table 5). Findings were similar to our primary analysis when rapid eGFR decline was defined as ≥3% decline in eGFR between waves three and four (Supplemental Table 6). Among individuals with new unemployment at HANDLS wave three (N=227), housing insecurity was associated with rapid eGFR decline and albuminuria, but not incident reduced eGFR (Supplemental Table 7).

Discussion

In this prospective cohort study of 1262 urban-dwelling individuals, housing insecurity was associated with subsequent albuminuria, but not rapid kidney function decline or incident reduced kidney function. Increasing number of sources of financial resource strain (*i.e.*, housing insecurity, food insecurity, unemployment, and inability to afford medical care) was associated with greater risk of albuminuria.

The relationship between adequate housing and public health in the United States has been discussed in the literature since the early 20th century, when infectious diseases and injury in overcrowded urban tenements led to national housing programs as a part of public health efforts (13,14). Since that time, it has become evident that poverty and other social determinants of health also affect noncommunicable diseases such as kidney disease (11,12,15–25). However, literature specifically evaluating the effect of housing on kidney disease is sparse and varied. A 2009 study in Singapore found that individuals with crowded living conditions were more likely to have albuminuria than those living in private housing or apartments with more bedrooms (26). In a prospective study in the United Kingdom, being behind on rent or mortgage payments was not associated with serum creatinine level over a 2-year period (27). Our findings contribute to the literature by evaluating the relationship of housing insecurity in the United States and subsequent kidney disease.

Housing insecurity has been associated with multiple CKD risk factors. Individuals with housing insecurity had increased risk of hypertension compared with their stably housed counterparts in the Coronary Artery Risk Development in Young Adults Study (4). A 2011 study that included 711 low-income adults with diabetes found that those without a usual place to stay had lower diabetes self-efficacy than those who owned their own home (5). In people living with HIV, housing insecurity has been associated with reduced odds of virologic suppression (28).

The link between housing insecurity and health outcomes may stem, in part, from diversion of financial resources that could otherwise be spent on health-promoting activities (*e.g.*, healthful eating and exercise) and medical care (15,29). This has been suggested in analyses of other measures of low socioeconomic status. In a mediation analysis by Vart *et al.* (30), 11% of the association between low socioeconomic status and prevalent CKD was attributed to self-reported lack of healthcare access and routine healthcare visits. In the setting of housing insecurity, medical care may be less of a priority and healthy behaviors may be unattainable (3). Food insecurity may lead to dietary supplementation with less expensive, unhealthy foods (31–33). Exercise may not be feasible or safe in low-income neighborhoods (34–36) and cigarette consumption has been associated with poverty level (37–40).

We found no statistically significant association between housing insecurity and rapid kidney function decline or incident reduced eGFR. Excluded participants were older and more likely to be male and report income <125% of the federal poverty level, which may have introduced selection bias toward the null. In sensitivity analyses, housing insecurity and increasing resource strain score were associated with rapid kidney function decline among people with new unemployment. There was potentially inadequate sample size or follow-up time for rapid kidney function decline and incident reduced eGFR to develop in the overall cohort. Albuminuria is sometimes associated with an acute increase in eGFR (41,42), then an eGFR decline over time (43). Whether ongoing exposure to housing insecurity increases risk for reduced eGFR over time, especially in those who develop albuminuria, warrants further study.

There was a trend toward a stronger association between housing insecurity and incident albuminuria for white participants. This may suggest that other factors, such as *APOL1* risk status, are stronger drivers of albuminuria risk among black people (44). Confirmation of the interaction between race and housing insecurity in other cohorts is needed.

Some limitations of our study bear mention. Traditional measures of housing insecurity, such as information on participant income, housing costs, and home crowding were not available, and therefore our housing insecurity definition may not have captured all participants experiencing housing insecurity. However, results from a sensitivity analysis using a composite definition of housing insecurity were similar to the primary analysis. We do not know the temporal relationship between housing insecurity and

Table 3. Risk of rapid eGFR decline, incident reduced eGFR, and incident albuminuria associated with financial resource strain score

Analysis	Regression Estimate
Rapid eGFR decline (N=1262), incidence ratio (95% CI)	
Model 1	1.12 (1.02 to 1.23)
Model 2	1.11 (1.02 to 1.20)
Model 3	1.10 (1.00 to 1.21)
Incident eGFR<60 ml/min per 1.73 m^2 (N=1220), odds ratio (95% CI)	
Model 1	1.00 (0.84 to 1.20)
Model 2	1.05 (0.87 to 1.26)
Model 3	1.01 (0.83 to 1.23)
Incident ACR ≥30 mg/g (N=1120), odds ratio (95% CI)	
Model 1	1.43 (1.14 to 1.80)
Model 2	1.44 (1.18 to 2.81)
Model 3	1.30 (1.01 to 1.68)

The financial strain score ranged from zero to four according to the number of financial resource strain indicators present (housing insecurity, food insecurity, ability to afford medications, and unemployment). Model 1 was unadjusted; model 2 was adjusted for baseline age, sex at birth, black/white race, and poverty status; model 3 was adjusted for demographics, eGFR, ACR, systolic BP, diabetes status, and education. CI, confidence interval; ACR, albumin-to-creatinine ratio.

covariables measured at baseline. Our cohort was moderately sized with relatively short follow-up, and our findings may not be generalizable to nonurban populations during different time periods. We treated cumulative financial resource strain as a continuous score to be consistent with past studies using measures of resource strain (45,46). However, we were not able to measure the relative weight or significance of each measure in the score, which may differ for each individual. Additional studies are needed to determine the best way to measure and analyze this variable. Strengths of our study include its prospective, longitudinal design, and our ability to assess housing insecurity during a specific time period when it was prominent. We do not, however, believe findings would differ during periods of economic growth. The financial resource strain score used in this study requires validation.

We found that housing insecurity was associated with subsequent albuminuria independent of demographic and clinical factors. Increased recognition of housing insecurity as a social determinant of kidney disease is needed, and risk-reduction efforts that specifically target populations experiencing housing insecurity should be considered.

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Author Contributions

D. Crews, M. Evans, T. Novick, and A. Zonderman were responsible for methodology and resources; D. Crews, D. Han, T. Novick, and C. Omenyi conceptualized the study; D. Crews and T. Novick reviewed and edited the manuscript; M. Evans, D. Han, T. Novick, and A. Zonderman were responsible for data curation; D. Han and T. Novick were responsible for formal analysis; T. Novick wrote the original draft.

Disclosures

D. Crews, M. Evans, D. Han, T. Novick, C. Omenyi, and A. Zonderman have nothing to disclose.

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Supplemental Material

This article contains the following supplemental material online at http://kidney360.asnjournals.org/lookup/suppl/doi:10.34067/KID.0000032019/-/DCSupplemental.

Supplemental Table 1. Housing variables in HANDLS.

Supplemental Table 2. Odds of incident eGFR<60 stratified by eGFR >90 and eGFR 60–90 ml/min/1.73m^2.

Supplemental Table 3. Odds of albuminuria stratified by race.

Supplemental Table 4. Sensitivity analysis: composite outcomes.

Supplemental Table 5. Sensitivity analysis: composite exposure.

Supplemental Table 6. Risk of 3% decline in eGFR between waves 3 and 4.

Supplemental Table 7. Sensitivity analysis: restricted to incident unemployed.

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