
Housing Instability and Incident Hypertension in the CARDIA Cohort

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ABSTRACT *Housing instability, a growing public health problem, may be an independent environmental risk factor for hypertension, but limited prospective data exist. We sought to determine the independent association of housing instability in early adulthood (year 5, 1990–1991) and incident hypertension over the subsequent 15 years of follow-up (years 7, 10, 15, and 20) in the Coronary Artery Risk Development in Young Adults (CARDIA) study (N=5,115). Because causes of inadequate housing and its effects on health are thought to vary by race and sex, we hypothesized that housing instability would exert a differential effect on incident hypertension by race and sex. At year 5, all CARDIA participants were asked about housing and those free of hypertension were analyzed (N=4,342). We defined housing instability as living in overcrowded housing, moving frequently, or living doubled up. Of the 4,342 participants, 8.5 % were living in unstable housing. Across all participants, housing instability was not associated with incident hypertension (incidence rate ratio (IRR), 1.1; 95 % CI, 0.9–1.5) after adjusting for demographics, socioeconomic status, substance use, social factors, body mass index, and study site. However, the association varied by race and sex (p value for interaction, <0.001). Unstably housed white women had a hypertension incidence rate 4.7 times (IRR, 4.7; 95 % CI, 2.4–9.2) that of stably housed white women in adjusted analysis. There was no association among white men, black women, or black men. These findings suggest that housing instability may be a more important risk factor among white women, and may act independently or as a marker for other psychosocial stressors (e.g., stress from intimate partner violence) leading to development of hypertension. Studies that examine the role of these psychosocial stressors in development of hypertension risk among unstably housed white women are needed.*

KEYWORDS *Housing instability, Hypertension, Access to care, Socioeconomic factors*

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INTRODUCTION

Housing instability, a precursor to homelessness, may be an independent risk factor for poor health. Housing instability is described in the sociological literature but lacks a standard definition. Definitions include living doubled up with family or friends or moving frequently due to an inability to pay rent, living in overcrowded conditions, or spending more than 50 % of household income on rent.¹⁻⁶

Housing instability, a growing public health problem, has received national attention because of the lack of affordable low-income housing, the foreclosure crisis, and rising unemployment.^{7,8} The number of people living doubled up (one definition of housing instability) increased by 5 % from 4.6 million in 2005 to 4.8 million adults in 2008.⁹ In 2009, when poverty rates reached a 15-year high, the number of people living doubled up with family or friends increased by 11.6 % compared to 2008.^{8,10}

Recurrent housing instability can lead to homelessness.⁴ Blacks and men are disproportionately represented among homeless adults.¹¹ While white women are least likely to experience homelessness, those who are homeless comprise a uniquely vulnerable group with respect to psychosocial risk factors that are distinct from being black or male.^{12,13}

Homeless adults face barriers to receiving health care,^{14,15} suffer from chronic medical conditions including hypertension,¹⁶⁻¹⁸ and experience premature mortality from cardiovascular disease.^{19,20} Studies among unstably housed adults demonstrate similar barriers to receiving health care,^{1,21} but little is known about health outcomes.

Hypertension is common among economically disadvantaged individuals.^{22,23} Social and environmental stressors of poverty may contribute to hypertension by augmenting physiological stress, or affecting diet and physical activity, and access to health care.²⁴ Known social and environmental stressors associated with incident and prevalent hypertension include poor neighborhood conditions,²⁵ homelessness,²⁶ job insecurity,²⁷ daily interpersonal conflicts,²⁸ incarceration,²⁹ and racial discrimination.³⁰

We hypothesized that housing instability is an important independent social and environmental risk factor for incident hypertension. We sought to determine the independent association of housing instability at year 5 and incident hypertension at years 7, 10, 15, and 20 in the Coronary Artery Risk Development In young Adults (CARDIA) study. Because causes of housing instability and its effects on health may vary by race and sex, we hypothesized, a priori, that the association between housing instability and incident hypertension would differ by race and sex. As access to care is important for treatment of hypertension, we also examined if housing instability was associated prospectively with barriers to receiving health care.

METHODS

The CARDIA study is a longitudinal cohort study examining the development of clinical and subclinical cardiovascular disease.^{31,32} In 1985-1986, 5,115 black and white men and women aged 18-30 years were recruited from four US cities (Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California). Sampling rates were controlled to balance the cohort by age (45 % aged 18-24 years and 55 % aged 25-30 years), sex (55 % male and 45 % female), race (52 % black and 48 % white), and education level (40 % with ≤high school and 60 % ≥high school). Participants were asked to return for follow-up examinations during 1987-1988 (year 2), 1990-1991 (year 5), 1992-1993 (year 7), 1995-1996

(year 10), 2000–2001 (year 15), and 2005–2006 (year 20) at each center. Retention rates were 91 % at year 2, 86 % at year 5, 81 % at year 7, 79 % at year 10, 74 % at year 15, and 72 % at year 20. Because questions on housing were asked at year 5 (1990–91) in CARDIA, this year served as the baseline for this analysis. Of the 5,115 participants recruited in 1985–1986, 4,342 who completed the year 5 examination and were free of hypertension at that time were analyzed.

HOUSING INSTABILITY

At year 5 (1990–1991), CARDIA participants were asked about frequent moves, housing crowding, and occupying a place without rent or money. We created a composite measure of housing instability, which we defined as >2 persons per bedroom (total number of people living in the household including children/number of bedrooms in the household),³³ or moving frequently (eight or more moves in the past 2 years, excluding people who were currently in school, college or graduate school) or currently occupying a place without paying rent or money as a proxy for living doubled up.^{1–5} For the latter component, participants were asked, “Is the home where you live: owned or being bought by you (or someone else in the household), rented for money, or occupied without paying rent or money?” Participants who reported living in a home that was occupied without paying rent or money were considered as living doubled up.

INCIDENT HYPERTENSION

At each CARDIA exam, trained and certified research staff measured right-arm blood pressure using a random-zero sphygmomanometer until the year 20 exam, when concerns about mercury in the apparatus required a switch to the OmRON sphygmomanometer. We used the average of the second and third blood pressure readings and defined hypertension as systolic blood pressure of ≥ 140 mmHg, diastolic blood pressure of ≥ 90 mmHg, or self-reported use of anti-hypertensive medications. We used incident hypertension at years 7, 10, 15, and 20 as the primary, discrete-time survival outcome for this analysis among study participants who did not meet the definition at any earlier visit.

ACCESS TO HEALTH CARE

We created three indicators of lack of access to health care: lack of a usual place to receive care, an unmet need for medical care, and lack of health insurance. Participants were asked at years 7, 10, 15, and 20, “Do you have a usual source of medical care? By that, we mean the place you go if you need a check-up or if you are ill?” Persons answering no to this question or reporting walk-in clinic or emergency room as their usual source of care were coded as lacking a usual source of care. Participants were coded as having an unmet need for medical care if they answered yes to the question, “Was there anytime during the past two years when you did not seek medical care because it was too expensive or health insurance did not cover it?” Participants were coded as lacking health insurance if they answered no to the question, “In the past two years have you always had health insurance or other medical coverage for health care?” We measured access to health care outcomes at years 7, 10, 15, and 20.

POTENTIAL CONFOUNDERS

We used time-varying covariates from all examinations between years 5 and 20 for all potential confounders of the association of housing instability and incident hypertension. We defined socioeconomic status by both education (\leq high school or $>$ high school) and annual income. The latter was based on combined family pre-tax income for the past 12 months, including income from wages, veteran's benefits, help from relatives, and rental receipts from properties. "Low-income" was defined as less than \$24,999 (i.e., <200 % of the federal poverty level for one-person households in 2010).³⁴

We created a dichotomous variable for married/partnered versus not (single, widowed, divorced, or separated). We defined presence of children as a three-level categorical variable: having no children or stepchildren, having children and/or stepchildren not living at home, or having children and/or stepchildren living at home.

Current smokers were those who reported smoking at least five cigarettes weekly for the last 3 months, in contrast to former and never smokers. Excess alcohol use, based on a consumption survey,³⁵ was defined as >7 drinks/week for women, and >14 drinks/week for men, with a drink defined as 360 ml of beer, 150 ml of wine, or 45 ml of liquor.³⁶ Current use of cocaine or amphetamines was based on self-report of any consumption in the past 30 days, versus former use (ever used, but not in last 30 days), or never having used.

Body mass index (BMI) was calculated as weight in kilograms divided by height in square meters, and used as continuous variable. Analysis included study site at year 5 (1990–1991) as housing instability could differ by city.

POTENTIAL MEDIATORS

We examined depression as one potential mediator of the association of housing instability and incident hypertension. The CES-D instrument was used to obtain information on depressive symptoms at years 5, 10, 15, and 20.^{37–39} We categorized participants as having higher depressive symptoms when they had CES-D scores of ≥ 16 , lower depressive symptoms when they had CES-D scores of ≤ 7 , and intermediate symptoms when their scores fell in between these two cut-offs.³⁷

STATISTICAL ANALYSIS

We considered year 5 (1990–1991) as the baseline for this analysis, and examined incident hypertension outcomes at years 7, 10, 15, and 20. Because we hypothesized that the effects of housing instability would vary by race and sex, we assessed potential differences in the effects of housing instability among white women, white men, black women, and black men. We compared study participants with and without housing instability using the t-test for continuous variables and chi-square test for categorical variables. Because we had interval-censored data, we used Poisson regression to estimate the unadjusted annual incidence of hypertension by housing status for the whole cohort and for each of the four race and sex groups. Using Poisson regression, we determined the adjusted incidence rate ratios (IRR) of hypertension by housing status, controlling for study site, sex, race, and other time-varying confounders such as age education, income, marital/partnered status, children, smoking, alcohol, cocaine, amphetamine use, and BMI. We tested for

two-way interaction between housing instability and race and sex and examined the association between housing instability and incident hypertension for each of the four race and sex groups controlling for covariates and other time-varying confounders. Because definitions of housing instability vary, we repeated these analyses on the subset of unstably housed adults who were only living in crowded housing as a sensitivity analysis. To assess the effect of depression as a potential mediator, we first examined the association between housing instability and depression using ordinal logistic regression controlling for covariates and time-varying confounders, and then looked for attenuation of the IRR after adding depression to the model with incident hypertension, housing instability, and other confounders. To assess the independent effects of housing instability on lack of access to care at years 7, 10, 15, and 20, we used multivariable logistic regression, accounting for repeated measurements of the outcome and covariates, and adjusting for demographics, socioeconomic status, social factors, behavioral risk factors, and study site. We conducted all analyses using Stata, version 11 (Stata Corp, College Station, TX).

RESULTS

Of the 4,342 participants, 370 (8.5 %) reported living in unstable housing at year 5 (Table 1). The prevalence of housing instability in white women was 5.0 % (59/1,179), white men 6.6 % (69/1,052), black women 11.7 % (142/1,212), and black men 11.1 % (100/899). The majority of adults living in unstable housing reported low annual incomes, with unstably housed white and black men and women more likely to report low annual incomes compared to their stably housed counterparts.

Among those who were stably housed at year 5, 21.4 % developed incident hypertension over the subsequent 15 years, with an unadjusted annual incidence of 1.2 %. In contrast, 27.4 % of unstably housed adults developed incident hypertension over this interval, with an unadjusted annual rate of 1.7 % (Table 2; Figure 1). Among all participants combined, after adjusting for potential confounders including demographics, socioeconomic status, social factors, behavioral factors, BMI, and study site, adults living in unstable housing had a hypertension incidence rate of 1.1 times greater than those in stable housing, though these results did not attain statistical significance (IRR, 1.1; 95 % CI, 0.9–1.5) (Table 2).

The association of housing instability and incident hypertension varied by race and sex (p value for interaction, <0.001), with incident hypertension more likely to occur in white women living in unstable housing relative to their stably housed counterparts. The unadjusted annual incidence rate of hypertension was 1.6 % for white women living in unstable housing compared with 0.5 % for white women in stable housing (Figure 1). After adjusting for potential confounders, unstably housed white women had an incidence rate four times (IRR, 4.7; 95 % CI, 2.4–9.2) that of stably housed white women (Table 2). For all other race and sex groups, rates of hypertension incidence did not vary by housing status.

In sensitivity analysis, we restricted the definition of housing instability to participants living in crowded housing ($n=181$ at year 5) and found similar results. Across the whole cohort, adults living in crowded housing at baseline had 1.3 (IRR, 1.3; 95 % CI, 1.0–1.8) times the rate of incident hypertension relative to those living in un-crowded housing after adjusting for potential confounders, though this association did not attain significance. However, there were differences by race and sex (p value for interaction, <0.001). White women living in crowded housing had

TABLE 1 Characteristics of adults living in unstable housing at year 5 (1990–1991; CARDIA, N=4,342)

Characteristics	Unstable housing (N (%))	Stable housing (N (%))	<i>p</i> value
All participants (N=4,342)	370 (8.5)	3,972 (91.5)	
Age (mean (SD))	29.0 (3.6)	30.1 (3.6)	<0.001
Low annual income (<\$24,999/year)	210 (58.5)	1,426 (36.5)	<0.001
High school or less	255 (68.9)	2,102 (52.9)	<0.001
Married or partnered	199 (53.8)	2,129 (53.6)	0.9
No children	151 (41.0)	2,001 (50.6)	<0.001
Have children but not living at home	24 (6.5)	284 (7.2)	
Have children and living at home	193 (52.5)	1,673 (42.3)	
Tobacco use (current or former)	212 (57.3)	2,316 (58.3)	0.7
Cocaine use (current or former)	54 (14.8)	309 (7.9)	<0.001
Amphetamine use (current or former)	80 (21.9)	1,034 (26.3)	0.07
Excess alcohol use (current or former)	34 (11.9)	291 (8.8)	0.08
BMI (mean (SD))	27.1(6.8)	26.1 (5.8)	<0.001
White women (N=1,179)	59 (15.9)	1,120 (28.2)	
Age (mean (SD))	29.2 (3.7)	30.6 (3.4)	<0.003
Low annual income (<\$24,999/year)	28 (48.3)	278 (25.1)	<0.001
High school or less	35 (59.3)	414 (36.9)	<0.001
Married or partnered	37 (62.7)	712 (63.6)	0.9
No children	30 (50.9)	660 (59.0)	0.2
Have children but not living at home	0 (0.0)	26 (2.3)	
Have children and living at home	29 (49.2)	432 (38.6)	
Tobacco use (current or former)	37 (62.7)	684 (61.1)	0.8
Cocaine use (current or former)	3 (5.2)	37 (3.3)	0.4
Amphetamine use (current or former)	24 (40.7)	417 (37.5)	0.6
Excess alcohol use (current or former)	2 (4.9)	70 (7.1)	0.6
BMI (mean (SD))	27.3 (7.4)	24.2 (5.1)	<0.001
White men (N=1,052)	69 (18.7)	983 (24.8)	
Age (mean (SD))	28.6 (3.2)	30.6 (3.3)	<0.001
Low annual income (<\$24,999/year)	34 (50.8)	254 (26.1)	<0.001
High school or less	41 (59.4)	408 (41.5)	<0.004
Married or partnered	30 (43.5)	549 (55.9)	<0.05
No children	47 (68.1)	653 (66.7)	0.5
Have children but not living at home	5 (7.3)	44 (4.5)	
Have children and living at home	17 (24.6)	283 (28.9)	
Tobacco use (current or former)	45 (65.2)	627 (63.8)	0.8
Cocaine use (current or former)	8 (11.6)	50 (5.1)	<0.02
Amphetamine use (current or former)	26 (37.7)	385 (39.5)	0.8
Excess alcohol use (current or former)	9 (14.5)	75 (8.4)	0.1
BMI (mean (SD))	25.6 (5.3)	25.6 (4.1)	0.9
Black women (N=1,212)	142 (38.4)	1,070 (26.9)	
Age (mean (SD))	29.2 (3.7)	29.6 (3.9)	0.2
Low annual income (<\$24,999/year)	84 (61.3)	537 (51.2)	<0.03
High school or less	105 (73.9)	707 (66.1)	0.06
Married or partnered	80 (56.3)	472 (44.1)	<0.006
No children	36 (25.4)	375 (35.3)	<0.02
Have children but not living at home	3 (2.1)	48 (4.5)	
Have children and living at home	103 (72.5)	640 (60.2)	
Tobacco use (current or former)	64 (45.1)	550 (51.5)	0.2
Cocaine use (current or former)	14 (10.0)	93 (8.8)	0.6

TABLE 1 (continued)

Characteristics	Unstable housing (N (%))	Stable housing (N (%))	<i>p</i> value
Amphetamine use (current or former)	11 (7.9)	120 (11.3)	0.2
Excess alcohol use (current or former)	10 (9.4)	60 (7.6)	0.5
BMI (mean (SD))	28.8 (7.9)	28.1 (7.4)	0.3
Black men (N=899)	100 (27.0)	799 (20.1)	
Age (mean (SD))	28.8 (3.7)	29.3 (3.7)	0.2
Low annual income (<\$24,999/year)	64 (65.9)	357 (45.7)	<0.001
High school or less	74 (74.0)	573 (71.8)	0.6
Married or partnered	52 (52.0)	396 (49.6)	0.6
No children	38 (38.8)	313 (39.3)	0.5
Have children but not living at home	16 (16.3)	166 (20.8)	
Have children and living at home	44 (44.9)	318 (39.9)	
Tobacco use (current or former)	66 (66.0)	455 (56.9)	0.08
Cocaine use (current or former)	29 (29.3)	129 (16.4)	<0.002
Amphetamine use (current or former)	19 (19.4)	112 (14.2)	0.2
Excess alcohol use (current or former)	13 (16.7)	86 (13.0)	0.4
BMI (mean (SD))	25.7 (4.9)	26.5 (5.3)	0.1

For each characteristic, percent represent column percentages. For some characteristics, due to item non-response, percentages are higher than expected

7.4 times the rate of incident hypertension than white women living in un-crowded housing after adjusting for confounders (IRR, 7.4; 95 % CI, 3.5–15.4). There were no significant associations among white men (IRR, 1.8; 95 % CI, 0.4–7.5), black women (IRR, 1.0; 95 % CI, 0.7–1.6), or black men (IRR, 1.1; 95 % CI, 0.5–2.1).

We examined depression as a potential mediator of the association of housing instability and incident hypertension among white women. Depression was not significantly associated with housing instability among white women (adjusted odds

TABLE 2 Proportion of adults with incident hypertension between years 7 and 20, and unadjusted and adjusted incidence rate ratios of hypertension by housing status and race and sex (CARDIA, N=4,342)

	Unstable housing ^a Proportion with incident hypertension ^b	Stable housing Proportion with incident hypertension ^b	Unadjusted incidence rate ratio ^c , * (95 % CI)	Adjusted incidence rate ratio ^c , ^d , * (95 % CI)
Whole cohort	96/351(27.4)	815/3,816 (21.4)	1.4 (1.1–1.7)**	1.1 (0.9–1.5)
White women	17/59 (28.8)	121/1,120 (10.8)	3.5 (2.1–5.9)**	4.7(2.4–9.2)**
White men	14/69 (20.3)	212/983 (21.6)	0.9 (0.5–1.7)	0.9(0.4–1.8)
Black women	54/142 (38.0)	375/1,070 (35.0)	1.1 (0.8–1.5)	0.9(0.6–1.3)
Black men	30/100 (30.0)	263/799 (32.9)	0.8 (0.5–1.3)	1.0(0.6–1.6)

p*<0.001 for interaction for housing instability by race and sex; *p*<0.005

^aHousing unstable is defined as living in overcrowded conditions, moving eight or more times in 2 years, or occupying a place without paying rent or money, measured at year 5

^bProportion with incident hypertension between years 7 and 20

^cReference, adults living in stable housing

^dAdjusted for age, sex, race, income, education, marital/partnered status, children, smoking, cocaine, amphetamine, excess alcohol use, BMI, and study site at each visit between years 5 and 20

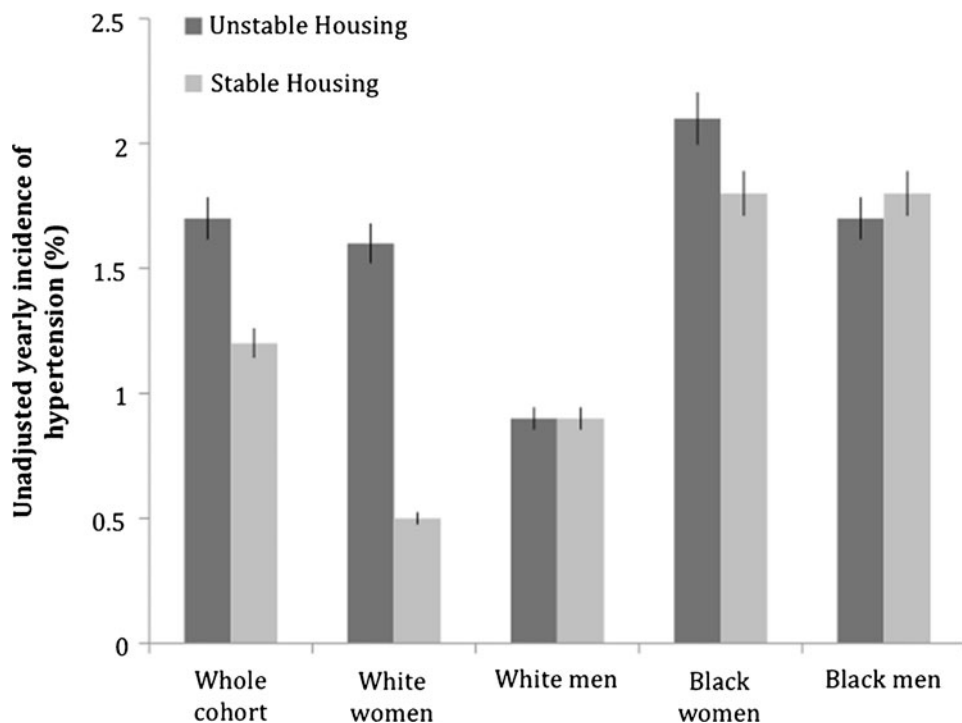


FIGURE 1. Unadjusted yearly incidence rates of hypertension by housing status and race and sex (CARDIA, $N=4,342$).

ratio (AOR), 1.0; 95 % CI, 0.6–1.6). While it did decrease the magnitude of IRR for housing instability in the final model with incident hypertension (IRR, 3.6; 95 % CI, 1.8–7.4), depression was not significantly associated with incident hypertension (IRR, 1.1; 95 % CI, 0.8–1.4).

When examining access to health care as an outcome, participants who were unstably housed at year 5 were more likely to lack a usual source of care (AOR, 1.6; 95 % CI, 1.3–1.9) and report an unmet need for medical care (AOR, 1.6; 95 % CI, 1.2–2.0) after controlling for potential confounders (Table 3). Participants in unstable housing were not more likely to lack health insurance relative to their stably housed counterparts after adjusting for potential confounders (AOR, 1.0; 95 % CI, 0.8–1.3). Compared with those who were stably housed, unstably housed white women, white men, and black women were more likely to lack a usual source of care. Unstably housed white and black men had greater odds of an unmet need for medical care compared with their stably housed counterparts.

DISCUSSION

In a well-characterized cohort of young adults living in four US cities, we examined the independent association between housing instability and incident hypertension. While there was no association between housing instability and incident hypertension across the cohort, there were significant interactions by race and sex. Unstably housed white women were at an increased risk of developing hypertension, whereas white men, black women and black men were not. The discordance by race and sex suggest that housing instability may reflect different phenomena and have

TABLE 3 Access to health care by housing status and race and sex (CARDIA, N=4,342)

	Lack of usual place of care*		Unmet need for medical care**		Lack of health insurance***	
	Unadjusted odds ratio (95 % CI) ^a	Adjusted odds ratio (95 % CI) ^{a, b}	Unadjusted odds ratio (95 % CI) ^a	Adjusted odds ratio (95 % CI) ^{a, b}	Unadjusted odds ratio (95 % CI) ^a	Adjusted odds ratio (95 % CI) ^{a, b}
Whole cohort	1.8 (1.5–2.1)*****	1.6 (1.3–1.9)*****	1.6 (1.3–2.0)*****	1.6 (1.2–2.0)*****	1.3 (1.1–1.6)*****	1.0 (0.8–1.3)
White women	1.6 (1.0–2.5)	1.7 (1.0–2.9)***	1.4 (0.9–2.5)	1.1 (0.6–2.1)	1.4 (0.8–2.4)	0.8 (0.4–1.8)
White men	1.8 (1.2–2.7)*****	1.7 (1.1–2.7)*****	2.6 (1.6–4.4)*****	2.2 (1.3–3.7)*****	1.9 (1.2–3.0)*****	1.4 (0.8–2.4)
Black women	1.9 (1.4–2.5)*****	1.7 (1.2–2.5)*****	1.1 (0.8–1.6)	1.2 (0.8–1.9)	1.1 (0.8–1.5)	0.9 (0.6–1.4)
Black men	1.3 (0.9–1.8)	1.1 (0.8–1.7)	2.3 (1.5–3.6)*****	1.9 (1.2–3.2)*****	1.0 (0.7–1.5)	0.9 (0.6–1.4)

^aReference group, adults living in stable housing

^bAdjusted for age, sex, race, income, education, marital/partnered status, children, smoking, cocaine, amphetamine, excess alcohol use, and study site at each visit between years 5 and 20

* $p=0.2$ value for interaction with race and sex; ** $p=0.1$ value for interaction with race and sex; *** $p=0.2$ value for interaction with race and sex; **** $p<0.005$; ***** $p<0.05$ value for interaction with race and sex

differential effects on hypertension incidence among black and white men and women. To our knowledge, this is the first longitudinal study examining the long-term effects of housing instability on hypertension incidence and could further our understanding of the role of social and environmental risk factors in development of cardiovascular risk.

Stably housed white women in the CARDIA cohort had the lowest baseline annual incidence of hypertension compared with white men, black women, or black men. Blacks and men had elevated baseline annual incidence rates of hypertension that did not differ significantly by housing status. These estimates of annual incidence of hypertension in black and white men and women are similar to those reported in prior studies.⁴⁰⁻⁴³ Notably, unstably housed white women lost the protective advantage while living in stable housing and had annual incidence rates of hypertension that exceeded not only stably housed white women but also approached the high rates seen in black women and men.

The differential effect of housing instability on hypertension incidence among white women may be partly due to the uneven distribution of social, behavioral and childhood risk factors for homelessness across race and sex groups. Recurrent housing instability can lead to homelessness as a result of selective accumulation of these social, behavioral, and childhood risk factors over time.^{4,12} White homeless women, when compared with homeless women of other racial/ethnic minorities and all homeless men, are more likely to experience mental health and substance use disorders, intimate partner violence, problematic childhood experiences such as foster care or institutional placement, childhood sexual and physical abuse, and family disruptions.^{12,13,44} To some extent, homelessness among black or Latina women stem more from extreme poverty or an inability to afford low-income housing, than from social, behavioral, or childhood risk factors that are significantly more prevalent among white women.^{13,45} Because of the increased burden of these stressors, white homeless women report worse self-reported health status, increased medical concerns, and hospitalizations than homeless women of racial/ethnic minorities.^{13,44,46} Although these studies were done among homeless adults, we posit that similar processes that increase risk for poor health may apply to unstably housed adults.

In our study, we found a differential association between housing instability and hypertension risk despite controlling for some of the socioeconomic, social, and behavioral risk factors that contribute to the development of housing instability. These findings suggest that, among white women, housing instability itself may be an independent risk factor, or may serve as a marker for other associated social or childhood experiences such as intimate partner violence or childhood sexual or physical abuse leading to the development of hypertension. Prior studies have shown that women with intimate partner violence or childhood sexual or physical abuse have an increased prevalence of hypertension.⁴⁷⁻⁵⁰ These stressors are more prevalent among homeless white women than among homeless women of other racial/ethnic minorities.^{12,13,44} Because we did not have access to specific measures on intimate partner violence or childhood abuse, we were unable to examine the independent effects of these stressors on the association between housing instability and incident hypertension. Studies that examine these stressors in conjunction with housing and in relation to hypertension would advance this line of inquiry.

We examined depressive symptoms as a mediator of the association of housing instability and incident hypertension because of the increased prevalence of psychological distress and mental illness among homeless white women,^{13,44} and also because depression was associated with hypertension in prior longitudinal

studies.^{37,51} Among white women, depression was not associated with housing instability. Adding depression to the final model did slightly attenuate the IRR, though it was not a significant independent predictor of incident hypertension, suggesting a lack of a mediating effect.

We did not observe an association between unstable housing and incident hypertension among black men or women. Biological factors such as increased salt sensitivity, and psychosocial factors such as stress related to severe poverty or discrimination are some of the postulated reasons for the higher rates of hypertension among blacks.^{52,53} Thus, housing instability, while disproportionate among blacks, may not reflect risk that exceeds other well-established biological causes and psychosocial stressors among black men and women.

Adults living in unstable housing had an increased likelihood of experiencing barriers to health care, and were more likely to lack a usual place of care and experience an unmet need for medical care compared with those who were stably housed. These findings are in agreement with prior studies linking housing instability with barriers to health care.^{1,21} In contrast to previous studies, there was no association between housing instability and access to health insurance after adjusting for potential confounders. As access to care is important for treatment and prevention of long-term complications of hypertension, these findings have implications for eliminating barriers to health care in this population.

We recognize several limitations. The components of our measure of housing instability are qualitatively different, potentially contributing to misclassification bias. We may have underestimated the number of people living doubled-up by excluding people living in a home that may have been bought or rented by someone else in their household, biasing our results towards the null. Measurements of housing instability and behavioral risk factors were by self-report, potentially resulting in underreporting that may differ by race and sex. We did not have information about housing status between years 7 and 20 limiting our ability to determine the duration and intensity of the exposure that may contribute to the development of hypertension. However, our data allowed us to estimate the effects of exposure to housing instability during early adulthood and provide evidence that an early-life stressful event may have downstream cardiovascular effects among certain groups. Understanding the mechanisms by which early adulthood stressors can lead to later development of cardiovascular risk can potentially stall the emergence of such risk factors. Because we had insufficient cases of incident hypertension at the earlier time points (years 7 and 10), we were unable to determine the effects of housing instability on transient hypertension. Being a white woman may not be the most salient descriptor of risk of hypertension among people experiencing housing instability. Other unmeasured risk factors for hypertension could discriminate a wider group of people across races in ways that are also associated with housing instability, and should be explored in future studies.

Despite these limitations, our data allowed us to calculate annual incidence of hypertension by housing status in a cohort of black and white men and women representative of the US population. Using two separate definitions of housing instability, we found an increased risk of hypertension among white women, but not in white men, black women, or black men, as well as barriers in access to care among all these groups. The inconsistency in our findings by race and sex suggests that housing instability may be a more important risk factor for hypertension in some groups. Unstably housed white women may be especially vulnerable to the development of hypertension due to psychosocial risk factors that are either

unmeasured in this study and for which the severity may be worse than other race and sex groups. Understanding the effects of housing instability and associated psychosocial stressors on hypertension risk among unstably housed white women may offer insights into the phenomenon of housing instability overall, and provide opportunities to improve screening, treatment, and prevention of long-term complications of hypertension among this population.

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