American Journal of Preventive Cardiology 22 (2025) 100967

Contents lists available at ScienceDirect

American Journal of Preventive Cardiology

journal homepage: www.journals.elsevier.com/american-journal-of-preventive-cardiology

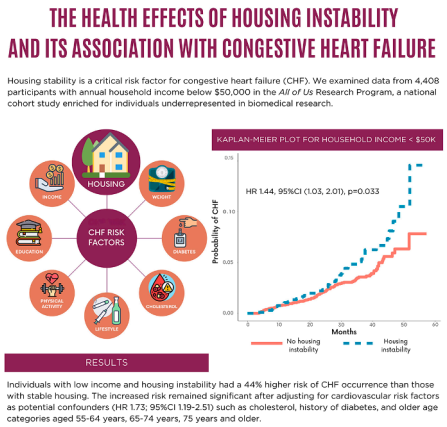
The health effects of housing instability and its association with congestive heart failure

Niloufar Novin [a,*], S. Scott Jones [b,c], Elizabeth Cohn [b,c], Nisha Parikh [b,c], David Zhang [b,c], Pey-Jen Yu [d], Kristie Coleman [d], Luis David Olivera Leon [d], Codruta Chiuzan [b,c]

[a] TouroCOM-Harlem, USA
[b] Northwell, New Hyde Park, NY, USA
[c] Institute of Health System Science, Feinstein Institutes for Medical Research, Manhasset, NY, USA
[d] Northwell Health, USA

GRAPHICAL ABSTRACT

Housing instability is linked to a 44 % higher risk of CHF in low-income individuals, as shown by Kaplan-Meier analysis. The association remains significant after adjusting for cardiovascular risk factors and age.



ARTICLE INFO

Keywords:
Heart failure
Chronic disease
All of Us data set
Unstable housing
Housing instability
Unhoused
Congestive heart failure
Social determinants of health
Healthcare disparity

ABSTRACT

Housing instability is a critical social determinant of health (SDOH). Prior studies of homelessness and congestive heart failure (CHF) have looked primarily at the association between socioeconomic status and hospitalization. The association between housing instability and the development of CHF has not been fully investigated.

We examined data from 4,408 participants with annual household income below $50,000 in the All of Us Research Program, a national cohort study enriched for individuals underrepresented in biomedical research. Within the inceptive survey, participants were asked if they were worried or concerned about not having a place to live in the past 6 months. We assessed the association between this self-reported housing concern and CHF occurrence, finding that individuals with low income and housing instability had a 44 % higher risk of diagnosis of CHF than those with stable housing (HR 1.44; 95 %CI 1.03–2.01). The increased risk remained significant after

* Corresponding author.
E-mail address: n1novin@student.touro.edu (N. Novin).

https://doi.org/10.1016/j.ajpc.2025.100967
Received 25 November 2024; Received in revised form 13 March 2025; Accepted 15 March 2025
Available online 17 March 2025

adjusting for cardiovascular risk factors as potential confounders (HR 1.73; 95 %CI 1.19–2.51) such as cholesterol, history of diabetes, and older age categories aged 55–64 years, 65–74 years, 75 years and older.

Compared with men, women in the study were estimated to be at lower risk of CHF diagnosis (HR 0.52; 95 % CI 0.38–0.70) with 5.3 % of men and 2.9 % of women eventually diagnosed. We found that participants with housing instability had a higher risk of diagnosis of CHF compared to those with stable housing, highlighting the potential health impact of this healthcare disparity. Housing instability disrupts the essentials of effective management of cardiovascular risk factors (diabetes, obesity, hypertension) including consistent management, reliable access to care, and access to basic needs like kitchen and bathroom. This exacerbates their severity and increasing the risk of being diagnosed with CHF.

1. Introduction

Housing instability, or housing insecurity, is a significant social determinant of health (SDOH), and an escalating public health concern [1–4]. This encompasses various conditions and challenges such as difficulty paying rent, spending a significant portion of income on housing, inconsistent housing, frequent moves, and living in poor or overcrowded conditions [5–8]. In 2023, we saw the highest record of homelessness since 2007 with an increase in nearly every state in the U.S [9]. Over 21 million renter households in the U.S. were considered cost-burdened, spending >30 % of their income on housing; and over 12 million renter households were considered severely cost-burdened, spending >50 % of their income on housing [10,11]. At the same time, pandemic relief programs like rental assistance, eviction moratoriums, and income assistance, are expiring [12]. With both housing instability and cardiovascular (CV) disease on the rise, housing has emerged as a critical public health concern [13].

Homelessness represents the most severe form of housing instability. In 2023, approximately 653,100 people experienced homelessness in the United States on a single night–a 12 % increase from 2022 [13]. A scientific statement by the American Heart Association (AHA) reported that individuals experiencing homelessness have a 60–70 % higher rate of cardiovascular events, including congestive heart failure, compared to the general population [13]. Economic challenges, housing instability, reduced access to healthcare, and chronic stress led to health inequities and poorer health outcomes, including higher risks for chronic conditions like congestive heart failure (CHF).

CHF is a common, chronic cardiovascular condition, affecting approximately 6.7 million adults in the United States and is projected to increase in prevalence to 8.7 million by 2030, 10.3 million by 2040, and 11.4 million by 2050 [14]. CHF is a leading cause of hospitalization among individuals over 65 with direct medical costs expected to reach $53 billion by 2030 [15]. Research has already established that housing instability is associated with a poorer control of hypertension and diabetes, both contributing risk factors to CHF [13,16,17].

Housing instability creates multifaceted barriers to accessing regular and preventive medical care. It is associated with inconsistent employment, lack of health insurance, frequent relocation, living in areas with limited healthcare resources, difficulty accessing transportation, and financial constraints, which use more healthcare resources and increase health care costs [18]. Patients with housing instability present later in the disease course, with more severe conditions and a higher burden of chronic illnesses, including diabetes, hypertension, and cardiovascular disease [17,19]. Despite high acute healthcare utilization, this population has difficulty accessing preventative care, which is necessary for managing and preventing chronic disease. Housing instability is associated with sleep health inequities and with a higher odds of concomitant substance use and mood disorders [20,21], both of which are linked to a higher risk of cardiovascular disease [22–24].

Consistent preventative care, medication adherence, and nutritional health are crucial for effective CHF management. Each one of these is challenged when experiencing housing instability [17]. We sought to better understand the relationship between housing instability and diagnosis of CHF.

2. Methods

2.1. Study population

The NIH's *All of Us* Research Program is a national, longitudinal cohort study enriched for participants underrepresented in biomedical research. Participants across the U.S. are enrolled in diverse settings such as health provider organizations, Federal Qualified Health Centers, local drug stores, and mobile units in communities. Upon enrollment, participants are asked to complete a set of surveys, biometric measures and blood are collected, and consent is obtained to access their electronic health record (EHR).

The *All of Us* workbench allows researchers to combine cross-sectional, self-reported survey data, with participant EHR. Fig. 1 illustrates inclusion criteria for analysis. As detailed in Fig. 1, dates of all available medical records ranged from 1939 to 2022. Housing instability status was derived from responses in "The Basics" survey if participants answered yes to following question: "In the past 6 months, have you been worried or concerned about NOT having a place to live?". The date associated with each survey response was used to define a baseline date for each participant. Therefore, collection dates for all self-reported data from "The Basics" ranged from 2017 to 2022. Participants who complete the initial enrollment survey but did not have available EHR data were excluded.

Available survey data in *All of Us* data version 7 included demographic data for 413,457 participants collected from 05/31/2017 to 06/30/2022. While demographic data collected by the initial enrollment survey ("The Basics") is available for all participants, responses to all survey questions are not required. Those missing sex, gender, ethnicity, race, marital status, education, income, and housing status were excluded, and of 310,667 remaining respondents, 211,770 had at least one recorded condition, observation, procedure, visit, drug/device exposure, or measurement. To remove pre-existing or concurrent CHF diagnoses at the time of *All of Us* enrollment, 8211 participants with a history of CHF were excluded from analysis, as their diagnosis date either preceded their survey response or followed their survey response by <90 days. Of 203,559 remaining participants, we included their data only if their latest available EHR timestamp exceeded survey response by at least 365 days; while this criterion eliminated 13,317 from analysis, this preserved comparable CHF diagnosis risk for the remaining 70,422 participants. We further restricted our analytic sample to participants with self-reported smoking status from the "Lifestyle" survey if completed within 90 days of "The Basics". Participants with unavailable or missing systolic blood pressure, cholesterol ratio, and BMI were omitted from analysis. Of the remaining 13,257 participants, 10.3 % reported housing concerns, with 77.4 % of those reporting annual household income below $50,000. With those earning 50 K or more representing 22.5 % of those reporting housing instability, we selected this income threshold as the upper bound of our final analytic sample. Finding self-reported housing instability at greater levels of annual income challenges the assumption that increased income removes anxiety associated with meeting basic necessities. Of those 3.5 % reporting housing concerns with income at 50 K or greater, 46 % reported an annual income of $50,000-$74,999, 20 % reported an annual income of

$75,000-$99,999, 17 % reported an annual income of $100,000-$149,999, 8 % reported an annual income of $150,000-$199,999, and 9 % reported an annual income of $200,000 or more. After imposing our income threshold, the resulting sample size did not permit inclusion of participants with non-cisgender identities; after excluding these 25 participants, the final analytic sample included 4408 participants.

All researchers who access the All of Us data for analyses are currently authorized and approved via a 6-step process that includes registration, affiliation with an institution that has completed a Data Use and Registration Agreement, identity verification via login.gov, completion of ethics training, and attestation to a data use agreement. Approval to use the dataset is covered by an IRB determination that this is a fully de-identified data set with research consent, and thus, additional IRB review is not required (letter attached). Results reported are in compliance with the All of Us Data and Statistics Dissemination Policy disallowing disclosure of group counts under 20 to protect participant privacy.

2.2. Outcome assessment - congestive heart failure (CHF)

A binary variable indicating CHF diagnosis was created from the EHR (SNOMED code 42343007 and corresponding ICD10 and ICD9 codes as listed in Supplemental Table 3). Where multiple records were found in EHR, the earliest record defined the date of CHF diagnosis. To ensure temporal inference, participant data were included for analysis only if the survey response (baseline date) preceded the CHF diagnosis by at least 90 days. The exclusion of those with diagnoses of CHF within 90 days of baseline (or enrollment "The Basics" survey submission) ameliorated concerns about pre-existing or concurrent CHF diagnoses in participants joining the study and initiated care at participating health facilities. Diagnosis dates of participants in the analytic sample ranged from 11/6/2018 to 6/23/2022.

2.3. Covariates

2.3.1. Demographics

Sex assigned at birth, gender identity, race and ethnicity, relationship status, annual household income, and highest level of education completed were collected in from the *All of Us* demographics "*Basics survey*". Cisgender participants were identified as those with concordant birth sex and gender identity. Date of birth for each participant was collected during consent and used to calculate age at the time of survey response. Age (years) was further divided into the following categories: 18–44, 45–54, 55–64, 65–74 and 75 years and above. These age categories are aligned with the age categories published in the National Center for Health Statistics.

Mutually exclusive racial and ethnic identity binary variables were created; first, all participants who endorsed "Hispanic, Latino, or Spanish" were coded as Hispanic/Latino/a/e/x; next, all non-Hispanic/Latino/a/e/x participants were coded as Multiracial if they endorsed multiple racial identities. The remaining participants were single endorsers of racial identity. Endorsers of "Asian", "Middle Eastern or North African", "American Indian or Alaska Native", "Native Hawaiian or other Pacific Islander", or "None of these fully describe me" were coded in a single category to avoid small group sizes in accordance with All of Us dissemination protocol which does not allow reporting for small cell sizes <20. Remaining identities of "Black, African American, or African" or "White" were coded as endorsed. A binary variable for relationship status was created to identify those who reported living with partners or being married.

2.3.2. Heavy drinking, stimulant use, and smoking

Survey data from the "Lifestyle" survey were combined with stimulant-related use, misuse, and abuse occurrences in EHR to create 2 binary variables: a binary indicator of heavy drinking and an additional binary indicator of recreational stimulant use (SNOMED codes 11061003, 228366006, 733461000, 66214007). The analytic sample included self-reported "Lifestyle" responses collected within 90 days after "Basics" survey response (participant baseline). The analytic sample included "Lifestyle" survey responses ranging from 6/5/2017 to 6/16/2021.

Participants were asked "How often did you have six or more drinks on one occasion in the past year?"; responses of "Daily", "Weekly", "Less Than Monthly", or "Monthly", were coded as heavy drinking. Similarly, participants were asked to report recreational use frequency ("Never", "Once or twice", "Monthly", "Weekly", "Daily" or "Almost daily") of cocaine, prescription stimulants (e.g. Ritalin), and other stimulants (e.g. meth) within the past 3 months; any reported use was coded as recreational stimulant use.

Additionally, any EHR entry referencing alcohol abuse or recreational stimulant use which preceded CHF diagnosis date and with timestamp within 1 year of baseline (housing instability survey response) was synthesized with self-reported alcohol and stimulant use and coded as heavy drinking and stimulant use. Datetime stamps for EHR referencing alcohol abuse or stimulant use in the analytic sample ranged from 365 days preceding baseline to 90 days following baseline.

A nicotine user/current smoker binary indicator was created from self-reported data collected by the "Lifestyle" survey. Respondents were asked "Do you smoke cigarettes every day, some days, or not at all?" and "Do you now use electronic nicotine products?"; endorsers of "Every day", or "Some days" were coded as nicotine users/current smokers.

2.3.3. Cardiovascular risk factors

Indicators of cardiovascular risk were selected from available EHR to align with the PREVENT™ heart disease risk calculator recently developed by the American Heart Association [25,26]. As calculated risk scores are validated only for specific ranges of risk factor values (ages 30–79, HDL 20–100 mg/dL, SBP 90–200 mmHg, BMI 18.5–39.9 kg/m^2, eGFR 15–140 mL/min/1.73 m^2), we opted to include each risk factor separately to avoid these limitations. Participant EHR with dates within 365 days prior to baseline (survey response) and preceding CHF diagnosis were included for analysis. Cholesterol ratio, SBP, and BMI values exceeding the 99th percentile were considered outliers and omitted from analysis. A mean was calculated where multiple observations or measurements existed for a participant within the allowable temporal range.

Systolic blood pressure was coded as a binary indicator to identify those with or without a value ≥130 mmHg. While the risk calculator included total cholesterol and HDL as separate metrics, we replaced these metrics with a single metric of cholesterol ratio to ameliorate concerns of collinearity. Participant eGFR and binary indicators of antihypertensive and statin status were omitted from analysis to address similar concerns. Individuals prescribed antihypertensive medications and statins were included in the analysis; however, we excluded indicators of these medications (diagnosis of hypertension, hyperlipidemia, etc.) from the multivariable analysis to avoid collinearity. A binary variable indicating diagnosis of diabetes mellitus (SNOMED code 73211009) was derived, and BMI categories were created for underweight (<18.5 kg/m^2), healthy weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obesity (≥30 kg/m^2) value ranges.

2.4. Data management and analysis

Data analysis was conducted within multiple Jupyter notebooks using R software version 4.4.0 and stored within the virtual environment provided by the All of Us Researcher Workbench. All data were derived from Controlled Tier Dataset V7. The ATHENA-OHDSI database was used to obtain Observational Health and Medicines Outcomes Partnership (OMOP) codes, Systemized Nomenclature of Medicine (SNOMED) codes, and equivalent diagnosis terms.

We compared demographic and clinical characteristics according to housing instability status and reported summary statistics as means and standard deviations for continuous variables, and frequencies

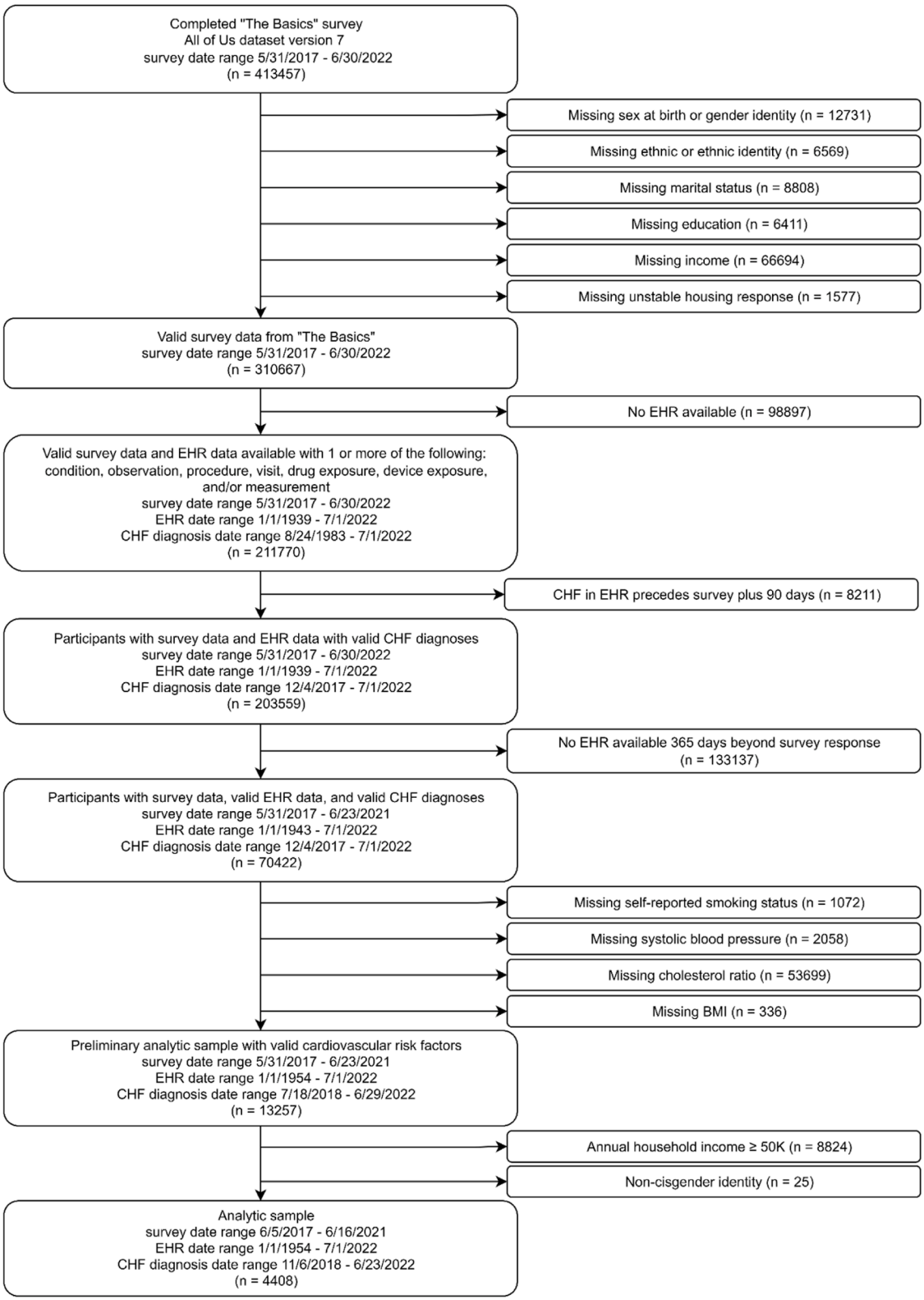


Fig. 1. Flow diagram showing inclusion criteria.

(percentages) for categorical variables. Group comparisons were evaluated using two-sided *t*-tests and Chi-Square tests.

We calculated time-to-CHF from the date of survey response (baseline) to the date of the diagnosis shown in the EHR records. Individuals with no CHF diagnosis were censored at 7/1/2022, which was the latest EHR date currently available within *All of Us* after application of our inclusion criteria.

The CHF probabilities were estimated using the Kaplan-Meier method. Univariable and multivariable Cox proportional hazards regression models were employed to test the associations between housing status (housing instability versus no housing concerns) and time to CHF. Independent variables were included in the multivariable model to align with the American Heart Association's PREVENT™ risk score calculator and maintain clinical relevance. Estimated hazard ratios among socioeconomic indicators showed only negligible changes in magnitude and no changes in directionality with the inclusion and exclusion of housing instability. Variance inflation factors (VIF) were all well below the accepted threshold of 10, indicating no evidence of multicollinearity among predictors.

The Cox proportionality assumption was tested for each of the variables considered in the model by including an interaction of that variable with the natural logarithm of time. There were no indications of proportionality violation. As death records were not available for every participant, participant data were included for analysis only if their latest available EHR timestamp exceeded baseline (survey response) by at least 365 days. Throughout these analyses, a 2-sided *p-value* <0.05 was considered statistically significant.

3. Results

Table 1 shows demographic and clinical characteristics of our sample with annual income less than $50,000 and stratified by housing instability status. Of the 4408 participants in this selected cohort, more than half (68 %) were cisgender women. The ages were distributed across most of the age groups from 18 to 74 years old, with the fewest participants 75 and older (10 %) and the most participants in the 18–44- and 55–64-year categories at 25 % each. By ethnicity and race, our study cohort was predominantly non-Hispanic White (55 %) while Asian, MENA, NHPI, AIAN, and Multiracial participants were the smallest population (4 %). We examined factors associated with the development of CHF including a history of alcohol use (42 %), stimulant use (4 %), being a current smoker (22 %), diabetes (25 %), systolic blood pressure greater than 130 (43 %) and increased cholesterol ratio (1 %).

Table 2 shows that the risk of CHF in our low-income sample was significantly higher among those with housing instability, with 4.8 % of those with housing concerns and 3.3 % of those with no housing concerns diagnosed (HR 1.44; 95 %CI 1.03–2.01). Cisgender men were more likely to report housing instability than women (27 % vs. 22 % respectively).

While the median time elapsed between baseline and CHF diagnosis was 955 days (2.61 years) overall, median time-to-diagnosis after survey response did not differ by housing status, with 959 days (2.63 years) elapsing for those with housing instability, and 955 days (2.61 years) elapsing for those with no housing concerns. As expected, an increase in age accompanies an elevated risk, with participants aged 55–64 (HR 2.14; 95 %CI 1.17–3.92), 65–74 (HR 2.92; 95 %CI 1.63–5.24), and 75 or older (HR 5.78; 95 %CI 3.19–10.47) significantly more likely to be diagnosed with CHF than those younger than 45. Univariable and multivariable analysis displayed in Supplemental Table 4 shows that continuous age, in alignment with categorical age, is significantly associated with CHF risk (HR 1.04, 95 % CI 1.04–1.07, $p < 0.001$). Among common cardiovascular risk factors, risk was elevated among those classified as obese (HR 1.86; 95 %CI 1.15–3.01), and those with a history of diabetes mellitus (HR 2.54; 95 %CI 1.87–3.47); 3.9 % of participants with BMI categorized as underweight, overweight, or obese were diagnosed with CHF, while 4.5 % of obese participants were diagnosed. Among participants with a history of diabetes mellitus, 6.7 % were diagnossed with CHF. Risk of CHF was increased proportional to total cholesterol/HDL ratio, with elevated values associated with increased risk (HR per unit increase in total/HLD cholesterol 1.18; 95 % CI 1.06–1.32).

Compared with men, women were estimated to be at lower risk of CHF diagnosis (HR 0.52; 95 %CI 0.38–0.70) with 5.3 % of men and 2.9 % of women diagnosed. Risk of CHF was lower among those identifying as Hispanic or Latino/a/e/x (HR 0.41; 95 %CI 0.26–0.65), with 1.9 % eventually diagnosed, compared to 4.2 % for those with non-Hispanic identities.

Estimated risk of CHF diagnosis in the multivariable model aligns with univariable risk estimates, with risk of CHF elevated for those with housing instability (HR 1.73; 95 %CI 1.19–2.51). Cholesterol (HR 1.18; 95 %CI 1.05–1.34) and history of diabetes (HR 2.35; 95 %CI 1.69–3.26) and older age categories [aged 55–64 years (HR 1.61; 95 %CI 1.01–3.51); 65–74 years (HR 3.46; 95 %CI 1.83–6.54); 75 years and older (HR 9.07; 4.56–18.01)] were associated with increased risk of CHF whereas identifying as Hispanic or Latino/a/e/x identity (HR 0.51; 95 % CI 0.30–0.87) was associated with lower risk of CHF. Supplemental Table 4 shows consistency of level of education, heavy drinking, recreational stimulant use, and smoking status were not significantly associated with elevated risk of CHF in univariable models. Hazard ratios for these variables remained statistically insignificant and shifted in magnitude only slightly in the multivariable model (Table 2), with directionality preserved.

Fig. 2 shows the Kaplan-Meier curves by housing status, risk table, and cumulative censoring for the analytic sample. Censoring occurred at approximately equivalent rates. On average, an additional 1.9 % of the at-risk sample was censored per month post-baseline among those with housing instability, compared to an average of 2.0 % per month of those with no housing concerns. Mean percentage rate of diagnosis differed, with 0.052 % of those with housing instability diagnosed per month, compared to 0.018 % of participants with no housing concerns.

Supplemental Table 1 describes participants with annual household income of $50,000 or more who were omitted from our analytic sample. While cisgender woman represented 68 % of the participants in our lower income group, 63 % reported housing instability status; though they constituted 58 % of the participants with higher income, a nearly identical proportion—64 %— reported housing concerns. As with participants in the lower income group, Supplemental Table 2 shows housing status among higher-income participants was associated with increased risk of CHF. Elevated risk for these participants was also associated with overweight or obese BMI.

Supplemental Table 3 lists relevant ID, name, code, and vocabulary of electronic health records as found in the *All of Us* workbench and ATHENA-OHDSI database.

4. Discussion

In this unique population, enriched for groups traditionally underrepresented in biomedical research including racial and ethnic

minorities, sex and gender minorities, and rural populations, we found that those with housing instability have a 44 % higher risk of CHF diagnosis than those with stable housing (HR 1.44; 95 %CI 1.03–2.01). The magnitude of effect between housing instability and CHF did not diminish upon multivariable adjustment for potential confounders (HR 1.73; 95 %CI 1.19–2.51).

Among patients with CHF, housing instability is related to higher in-hospital mortality and recurrent CHF hospitalizations [27–29]. In a nationwide study of patients with CHF, those who were either homeless or in a low median neighborhood income stratum had higher in-hospital mortality than those who were housed and in higher income strata [27]; these findings were consistent with a separate study of a Midwestern safety net hospital [28]. However, a separate analysis of patients from NY, CA and FL showed that risk adjusted mortality did not differ between homeless and housed patients who were hospitalized for CHF [29]. Steverson and colleagues in a California safety net hospital showed that the presence of homelessness and living in a shelter were both associated with recurrent CHF hospitalizations (with 2 and 3-fold increased risk respectively) [29].

To our knowledge, this is the first study to demonstrate a direct link between housing instability and increased risk of CHF in a diverse population sample. Housing instability is a significant societal and systemic risk factor for chronic disease, including cardiovascular disease. This finding is particularly relevant in the context of the ongoing housing crisis in the United States, which may be perpetuating and exacerbating chronic health conditions among vulnerable populations. Prior studies of homelessness and CHF have been primarily conducted within populations with CHF and have not examined the relative occurrence of CHF between those with and without housing instability [27]. Taken together these findings demonstrate that patients with housing instability have worse secondary outcomes once diagnosed with CHF.

Stable housing is an important ingredient in the successful prevention and treatment of CHF. Multiple medications are prescribed for management of cardiovascular risk factors (e.g., hypertension, diabetes), following a low salt diet is a key treatment for HTN and HF, and daily weights with a consistent scale is an important self- management step for patients. High housing costs impede a patient's ability to afford heart-healthy food, monitoring supplies, medications, and transportation to regular doctor appointments [6,7]. Because of the need for a kitchen to follow the recommendations and the first-line use of diuretics, which include frequent and necessary access to bathroom facilities, stable housing is imperative to disease management. Residing in unsafe neighborhoods and the associated stress of housing instability have lasting adverse health effects [6,7]. Substandard housing conditions, such as exposure to pollutants like mold and secondhand smoke, and inadequate temperature control, can further affect cardiovascular health [5–7,13].

The association between housing instability and CHF emphasizes the need for novel approaches to address housing as a critical determinant of health. Several housing policies and programs have shown promise in improving the health of vulnerable populations by addressing housing instability and related factors [30,31]. One example is Housing First programs, which offer permanent housing coupled with health and social services [30]. In 2019, the Kaiser Permanente Health Maintenance Organization started a series of Housing First initiatives. After providing long-term housing for 515 homeless older adult residents in Oakland, California, they saw a 37 % decrease in emergency department utilization and a 27 % reduction in health care costs overall [32]. Providing ride-share services to homeless veterans was associated with greater use of Veteran's Administration outpatient and inpatient services and fewer no-show medical appointments over six months [33]. Initiatives that offer individuals housing stability allow them to focus on their health and improve their well-being. These findings contribute to the growing body of evidence supporting housing as a medical intervention. This approach represents the need for a paradigm shift from traditional

Table 1
Analytic Sample for Household Income < $50K.

Characteristic	Total (n = 4408)	No Housing Concern (n = 3357)	Housing instability (n = 1051)	p
Sex and Gender				<0.001
Cisgender Woman	3000 (68 %)	2335 (70 %)	665 (63 %)	
Cisgender Man	1408 (32 %)	1022 (30 %)	386 (37 %)	
Age, yrs (mean (sd))	55.80 (15.94)	57.31 (16.41)	50.98 (13.27)	<0.001
Age, yrs (median (IQR))	58 (45–68)	60 (46–69)	53 (41–60)	<0.001
Age, yrs				<0.001
18–44[d]	1080 (24 %)	<770 (<23 %)	>296 (>28 %)	
45–54	768 (17 %)	486 (14 %)	282 (27 %)	
55–64	1082 (24 %)	788 (23 %)	294 (28 %)	
65–74	1018 (23 %)	873 (26 %)	145 (14 %)	
≥75[d]	460 (10 %)	>436 (>13 %)	<20 (<2 %)	
Ethnicity and Race				<0.001
Hispanic or Latino/a/e/x	1102 (25 %)	823 (25 %)	279 (27 %)	
Non-Hispanic Black	684 (16 %)	477 (14 %)	207 (20 %)	
Non-Hispanic White	2442 (55 %)	1922 (57 %)	520 (49 %)	
Non-Hispanic Asian, MENA/NHPI/AIAN, Other/Multiracial	180 (4 %)	135 (4 %)	45 (4 %)	
Highest Level of Education				<0.001
Less than HS/GED	500 (11 %)	343 (10 %)	157 (15 %)	
HS/GED	1005 (23 %)	736 (22 %)	269 (26 %)	
Some College	1549 (35 %)	1160 (35 %)	389 (37 %)	
College Degree	878 (20 %)	716 (21 %)	162 (15 %)	
Advanced Degree	476 (11 %)	402 (12 %)	74 (7 %)	
Annual Household Income				<0.001
<$10,000	947 (22 %)	569 (17 %)	378 (36 %)	
$10,000-$24,999	1437 (33 %)	1044 (31 %)	393 (37 %)	
$25,000-$34,999	858 (20 %)	712 (21 %)	146 (14 %)	
$35,000-$49,999	1166 (27 %)	1032 (31 %)	134 (13 %)	
Cohabitating or Married	1367 (31 %)	1104 (33 %)	263 (25 %)	<0.001
Congestive Heart Failure (CHF)	160 (4 %)	110 (3 %)	50 (5 %)	0.032
Heavy Drinking, past 12M[a]	1849 (42 %)	1302 (39 %)	547 (52 %)	<0.001
Stimulant Use, past 3M[b]	153 (4 %)	74 (2 %)	79 (8 %)	<0.001
Current Smoker[c]	987 (22 %)	595 (18 %)	392 (37 %)	<0.001
BMI, kg/m^2				0.124
Underweight, <18.5[d]	33 (1 %)	>21 (>1 %)	<20 (<2 %)	
Healthy weight, 18.5–24.9	820 (19 %)	630 (19 %)	190 (18 %)	
Overweight, 25.0–29.9	1327 (30 %)	1035 (31 %)	292 (28 %)	
Obese, ≥30.0[d]	2228 (51 %)	>1659 (>49 %)	>549 (>52 %)	
Diabetes mellitus	1120 (25 %)	808 (24 %)	312 (30 %)	<0.001

(continued on next page)

Table 1 (*continued*)

Characteristic	Total (n = 4408)	No Housing Concern (n = 3357)	Housing instability (n = 1051)	p
Systolic Blood Pressure ≥130 mmHg	1902 (43 %)	1449 (43 %)	453 (43 %)	0.999
Cholesterol Ratio, Total/HDL (mean (sd))	3.60 (1.19)	3.54 (1.14)	3.82 (1.32)	<0.001

[a] ≥6 drinks in one occurrence in last year or heavy alcohol consumption indicated in EHR;.

[b] cocaine, other stimulant (e.g. methamphetamine), prescription stimulant use in last 3 months or stimulant use indicated in EHR;.

[c] cigarette smoking or e-cigarette use reported at least 1 day each week.

[d] quantities masked in adherence to All of Us dissemination protocol.

medical interventions towards addressing broader social determinants of health.

There are some possible limitations in this study. Although we demonstrated an association between housing instability and CHF risk, we cannot assume housing instability causes CHF. Limitations inherent to the All of Us Research Program and how it accepts participants into its database also affected this study. The program requires enrollment through their online platform, meaning those without access to a phone, computer, or internet connection are excluded. Housing instability was ascertained based on a self-reported survey at a single time point, which would not capture the dynamic nature of how housing situations change over time. Furthermore, we exclude patients without at least one form of EHR contact at least 365 days after the initial All of Us Basics survey response and those with missing income data. Due to these limitations, we have likely underestimated both the prevalence of housing instability, and its impact on this vulnerable patient population. We used an income threshold of $50,000 to define the upper bound of our final analytic sample. Although the multivariable (adjusted) hazard ratio for housing instability in the larger sample (composed of all with complete data, without regard of annual household income) was statistically significant (HR 2.11; 95 %CI 1.54, 2.90, $p < 0.001$), we believe more research is needed to investigate housing instability at higher income levels. We present results within the intersection of limited economic resources and the economic challenges associated with accessing medical care and maintaining a chronic health condition.

The Cox regression used in our analysis estimates propensity of the sample to develop CHF. We need EHR data to confirm with certainty whether an individual developed CHF as well as to verify their mortality status. This will exclude those who do not receive medical care at a site that shares data with All of Us. This approach ensures data integrity, but potentially introduces selection bias as these requirements disproportionately exclude lower socioeconomic groups facing the most barriers to regular medical care. Nonetheless, the All of Us Research Program is enriched for groups traditionally underrepresented in biomedical research and we are still capturing communities that would typically not be included in this type of study. Lastly, our classification of CHF relied on ICD codes from the EHR, which are subject to physician input and interpretation. This introduces potential random misclassification of CHF diagnoses, which would have most likely biased our estimates towards the null. These limitations mean we are highly underestimating how much housing impacts health in our study.

Future research should support analyses to evaluate the health effects of housing-related programs. We suggest examination of multilevel constructs that include individual and contextual factors such as social determinants of health (e.g., neighborhood characteristics, food insecurity, transportation, and healthcare access, etc.), as well as participation in other social services/programs like Supplemental Nutrition Assistance Program (SNAP), Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), neighborhood revitalization, rental assistance, eviction prevention, or other programs. This comprehensive approach will evaluate how these factors may interact to impact prevention, onset, progression, and treatment of chronic disease and other health conditions.

Housing instability is one SDOH among a dynamic group of factors

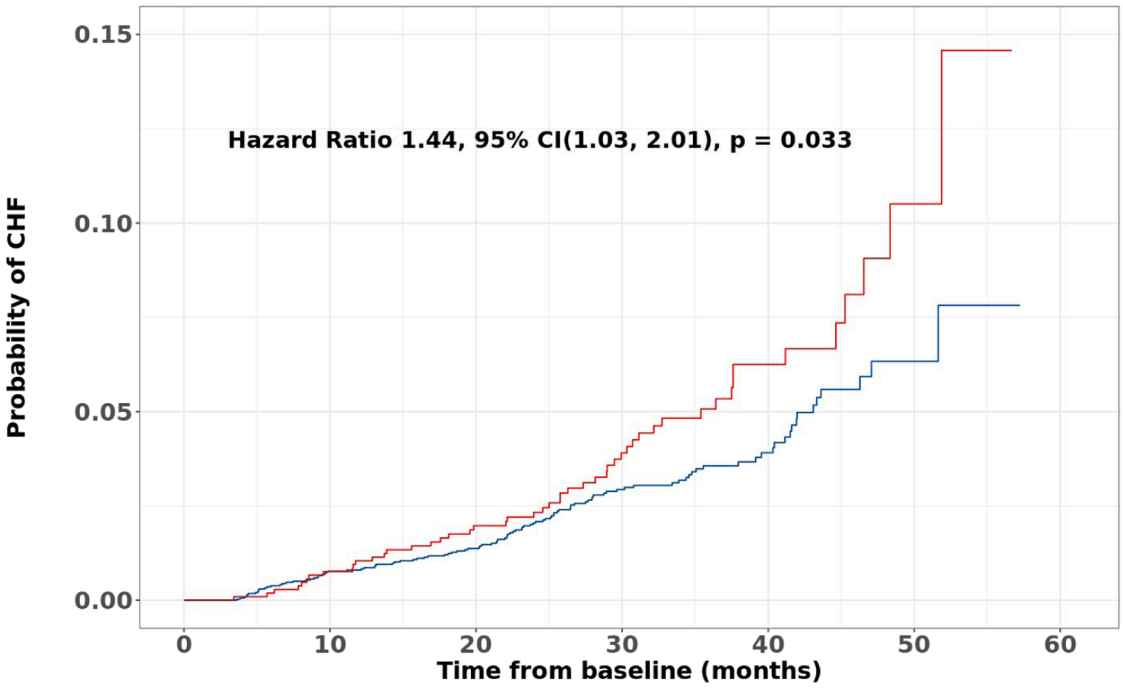
Table 2
Analysis Results for Household Income < $50K.

Characteristic	Univariable Cox Regression			Multivariable Cox Regression		
	HR	95 % CI	p	HR	95 % CI	p
Housing instability (ref no housing concern)	1.44	1.03, 2.01	0.033	1.73	1.19, 2.51	0.004
Cisgender Woman (ref Man)	0.52	0.38, 0.70	<0.001	0.61	0.44, 0.85	0.003
Age, yrs						
18–44 yrs (ref)						
45–54	2.11	1.11, 4.01	0.022	1.61	0.84, 3.09	0.151
55–64	2.14	1.17, 3.92	0.014	1.88	1.01, 3.51	0.047
65–74	2.92	1.63, 5.24	<0.001	3.46	1.83, 6.54	<0.001
≥75	5.78	3.19, 10.47	<0.001	9.07	4.56, 18.01	<0.001
Ethnicity and Race						
Non-Hispanic White (ref)						
Hispanic or Latino/a/e/x	0.41	0.26, 0.65	<0.001	0.51	0.30, 0.87	0.014
Non-Hispanic Black	0.88	0.58, 1.33	0.534	0.98	0.63, 1.55	0.945
Non-Hispanic Asian, MENA/NHPI/AIAN, Other/Multiracial	0.51	0.19, 1.39	0.188	0.70	0.26, 1.93	0.492
Highest Level of Education						
HS/GED (ref)						
Less than HS/GED	0.71	0.41, 1.25	0.239	0.85	0.47, 1.55	0.601
Some College	0.74	0.50, 1.11	0.146	0.72	0.48, 1.08	0.111
College Degree	0.74	0.47, 1.18	0.206	0.76	0.47, 1.23	0.259
Advanced Degree	0.64	0.36, 1.15	0.137	0.66	0.35, 1.21	0.178
Cohabitating or Married	0.92	0.66, 1.29	0.633	0.95	0.67, 1.35	0.788
Heavy Drinking, past 12 M (ref none)[a]	0.95	0.69, 1.30	0.748	1.21	0.85, 1.73	0.284
Stimulant Use, past 3 M (ref none)[b]	0.97	0.40, 2.38	0.955	0.88	0.35, 2.24	0.788
Current Smoker (ref nonsmoker)[c]	1.18	0.82, 1.69	0.371	1.29	0.85, 1.96	0.229
BMI, kg/m^2						
Healthy weight 18.5–24.9 (ref)						
Underweight <18.5	1.45	0.19, 10.78	0.719	1.41	0.19, 10.71	0.738
Overweight 25.0–29.9	1.20	0.70, 2.07	0.502	0.95	0.55, 1.64	0.844
Obese ≥30.0	1.86	1.15, 3.01	0.011	1.59	0.96, 2.65	0.072
Diabetes mellitus	2.54	1.87, 3.47	<0.001	2.35	1.69, 3.26	<0.001
Systolic Blood Pressure ≥130 mmHg	1.30	0.95, 1.77	0.100	0.90	0.65, 1.23	0.495
Cholesterol Ratio (Total/HDL)	1.18	1.06, 1.32	0.004	1.18	1.05, 1.34	0.007

[a] ≥6 drinks in one occurrence in last year or heavy alcohol consumption indicated in EHR.

[b] cocaine, other stimulant (e.g. methamphetamine), prescription stimulant use in last 3 months or stimulant use indicated in EHR.

[c] cigarette smoking or e-cigarette use reported at least 1 day each week.



No Housing Concern							
At Risk	3357	3331	2910	1873	744	107	0
Censored	0	0	403	1402	2517	3142	3247
Events	0	26	45	85	97	109	110
Unstable Housing							
At Risk	1051	1043	892	573	251	39	0
Censored	0	0	140	444	756	964	1001
Events	0	<20	20	34	44	49	50

Fig. 2. Kaplan-Meier Plot for Household Income < $50K.

that disproportionately affect marginalized populations in our communities. Interventions targeting housing instability could significantly reduce the prevalence and severity of chronic diseases like CHF, but more research is needed. Addressing this research gap will help support and guide public health initiatives, leading to improved outcomes not only for CHF but also overall population health. In our study, we have shown how housing plays a critical role in cardiovascular health and chronic disease, specifically in the occurrence of CHF. It is urgent for policymakers and public health practitioners to view housing as a tool to improve and prevent health disparities. The upfront cost of more affordable housing and supportive services will likely offset the downstream costs of hospitalizations and healthcare spending on chronic disease. We need public and private housing providers to create more equitable housing opportunities and effectively targeted solutions to help those long affected by housing disparities.

"The All of Us Research Program is supported by the National Institutes of Health, Office of the Director: Regional Medical Centers: 1 OT2 OD026549; 1 OT2 OD026554; 1 OT2 OD026557; 1 OT2 OD026556; 1 OT2 OD026550; 1 OT2 OD 026552; 1 OT2 OD026553; 1 OT2 OD026548; 1 OT2 OD026551; 1 OT2 OD026555; IAA #: AOD 16037; Federally Qualified Health Centers: HHSN 263201600085 U; Data and Research Center: 5 U2C OD023196; Biobank: 1 U24 OD023121; The Participant Center: U24 OD023176; Participant Technology Systems Center: 1 U24 OD023163; Communications and Engagement: 3 OT2 OD023205; 3 OT2 OD023206; and Community Partners: 1 OT2 OD025277; 3 OT2 OD025315; 1 OT2 OD025337; 1 OT2 OD025276. In addition, the All of Us Research Program would not be possible without the partnership of its participants.

CRediT authorship contribution statement

Niloufar Novin: Writing – review & editing, Writing – original draft, Resources, Project administration, Investigation, Conceptualization. **S. Scott Jones:** Writing – review & editing, Visualization, Validation, Software, Methodology, Formal analysis, Data curation. **Elizabeth Cohn:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Conceptualization. **Nisha Parikh:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Conceptualization. **David Zhang:** Writing – review & editing, Supervision, Investigation, Conceptualization. **Pey-Jen Yu:** Writing – review & editing, Supervision, Investigation, Conceptualization. **Kristie Coleman:** Writing – review & editing. **Luis David Olivera Leon:** Writing – review & editing, Investigation. **Codruta Chiuzan:** Writing – review & editing, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Dr. Elizabeth Cohn reports a relationship with IGNITE grant NIH 7OT20D031915-02 that includes: funding grants. Stephen Scott Jones reports a relationship with IGNITE grant NIH 7OT20D031915-02 that includes: funding grants. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ajpc.2025.100967.

References

[1] Bailey P. Housing and health partners can work together to close the housing affordability gap. Washington, DC: Center on Budget and Policy Priorities; 2020.
[2] Long CL, Franklin SM, Hagan AS, et al. Health-related social needs among older adults enrolled In Medicare Advantage. Health Aff (Millwood) 2022;41(4):557–62.
[3] Kottke T, Abariotes A, Spoonheim JB. Access to affordable housing promotes health and well-being and reduces hospital visits. Perm J 2018;22:17–079.
[4] Koeman J, Mehdipanah R. Prescribing housing: a scoping review of health system efforts to address housing as a social determinant of health. Popul Health Manag Jun 2021;24(3):316–21.
[5] Office of Disease Prevention and Health Promotion. Housing instability. U.S. Department of Health and Human Services; 2024. Available at: health.gov/healthypeople/priority-areas/social-determinants-health/literature-summaries/housing-instability. Accessed October 14.
[6] Kim H, Burgard SA. Housing instability and mental health among renters in the michigan recession and recovery study. Public Health 2022;209:30–5.
[7] Palimaru AI, McDonald K, Garvey R, D'Amico E, Tucker J. The association between housing stability and perceived quality of life among emerging adults with a history of homelessness. Health Soc Care Commun 2023;2023.
[8] Frederick TJ, Chwalek M, Hughes J, Karabanow J, Kidd S. How stable is stable? Defining and measuring housing stability. J Commun Psychol 2014;42(8):964–79.
[9] Office of Policy Development and Research (PD&R). 2023 Annual homeless aassessment report: part 1 - PIT Estimates of homelessness in the. U.S. Washington, DC: Office of Policy Development and Research (PD&R); 2023.
[10] National Low Income Housing Coalition. HUD releases 2023 annual homeless assessment report. National Low Income Housing Coalition; 2024. Available at: nlihc.org/resource/hud-releases-2023-annual-homeless-assessment-report. Accessed October 14.
[11] Joint Center for Housing Studies. America's rental housing. Joint Center for Housing Studies of Harvard University. Available at: jchs.harvard.edu/sites/default/files/reports/files/Harvard_JCHS_Americas_Rental_Housing_2024.pdf.
[12] Frost R. Record homelessness amid ongoing affordability crisis. Joint Center for Housing Studies of Harvard University; 2024. Available at: jchs.harvard.edu/blog/record-homelessness-amid-ongoing-affordability-crisis. Accessed October 14.
[13] Sims M, Kershaw KN, Breathett K, et al. Importance of housing and cardiovascular health and well-being: a scientific statement from the American Heart Association. Circ Cardiovasc Qual Outcome 2020;13(8):e000089.
[14] Bozkurt B, Ahmad T, Alexander K, Baker WL, Bosak K, Breathett K, Carter S, Drazner MH, Dunlay SM, Fonarow GC, et al. HF STATS 2024: heart failure epidemiology and outcomes statistics—an updated 2024 report from the Heart Failure Society of America. J Card Fail 2024. https://doi.org/10.1016/j.cardfail.2024.07.001.
[15] Osenenko KM, Kuti E, Deighton AM, Pimple P, Szabo SM. Burden of hospitalization for heart failure in the United States: a systematic literature review. J Manag Care Spec Pharm. Feb 2022;28(2):157–67.
[16] U.S. Centers for Disease Control and Prevention. Federal housing assistance and chronic disease among US adults, 2005–2018. U.S. Centers for Disease Control and Prevention; 2024. Department of Health and Human ServicesAvailable at: cdc.gov/pcd/issues/2023/23_0144.htm. Accessed October 14.
[17] Gu KD, Faulkner KC, Thorndike AN. Housing instability and cardiometabolic health in the United States: a narrative review of the literature, 23. BMC Public Health; 2023. p. 931. 2023/05/23.
[18] Franco A, Meldrum J, Ngaruiya C. Identifying homeless population needs in the emergency department using community-based participatory research, 21. BMC Health Services Research; 2021. p. 428. 2021/05/05.
[19] Saab D, Nisenbaum R, Dhalla I, Hwang SW. Hospital readmissions in a community-based sample of homeless adults: a matched-cohort study. J Gen Intern Med. Sep 2016;31(9):1011–8.
[20] Al-Khalil Z, Attarian H, Dunietz GL, Gavidia Romero R, Knutson K, Johnson DA. Sleep health inequities in vulnerable populations: beyond sleep deserts. Sleep Med X. Dec 2024;7:100110.
[21] Gutwinski S, Schreiter S, Deutscher K, Fazel S. The prevalence of mental disorders among homeless people in high-income countries: an updated systematic review and meta-regression analysis. PLoS Med 2021;18(8):e1003750.
[22] Redline S, Foody J. Sleep disturbances: time to join the top 10 potentially modifiable cardiovascular risk factors? Circulation 2011;124(19):2049–51.
[23] Solmi M, Fiedorowicz J, Poddighe L, et al. Disparities in screening and treatment of cardiovascular diseases in patients with mental disorders across the world: systematic review and meta-analysis of 47 observational studies. Am J Psychiatry 2021;178(9):793–803.
[24] Mazza M, Biondi-Zoccai G, Lisci FM, et al. The brain-Heart axis: an umbrella review on impact of psychiatric disease on incidence, management, and outlook of cardiovascular disease. Life (Basel) 2024;14(8).
[25] American Heart Association. Leading cardiologists reveal new heart disease risk calculator: cardiovascular, kidney and metabolic health measures included in new prevent risk calculator, detailed in a new American Heart Association Scientific Statement. American Heart Association. Available at: newsroom.heart.org/news/leading-cardiologists-reveal-new-heart-disease-risk-calculator. Accessed October 14, 2024.
[26] American Heart Association. PREVENT online calculator. American Heart Association. Available at: professional.heart.org/en/guidelines-and-statements/prevent-calculator. Accessed October 24, 2024.
[27] Averbuch T, MO Mohamed, Islam S, et al. The association between socioeconomic status, sex, race /ethnicity and In-hospital mortality among patients hospitalized for heart failure. J Card Fail 2022;28(5):697–709.
[28] Zellmer L, Chedid M, Mohandas A, Rodin H, Vickery KD, Shroff GR. Prevalence and impact of adverse social and behavioral determinants of health in heart failure: analysis of a safety-net population. J Health Care Poor Underserved 2024;35(2):503–15.
[29] Steverson AB, Marano PJ, Chen C, et al. Predictors of all-cause 30-day readmissions in patients with heart failure at an urban Safety Net hospital: the importance of social determinants of health and mental health. Am J Med Open. Dec 2023;10:100060.
[30] National Alliance to End Homelessness. Housing First. National Alliance to End Homelessness. Available at: endhomelessness.org/resource/housing-first/. Accessed October 14, 2024.
[31] O'Toole T. Development and expansion of homeless patient aligned care team (HPACT) model: H-pact program Brief Washington, DC: VA National Center on Homelessness Among Veterans.
[32] Oliva A., Davis V. Housing first is a matter of health. Kaiser Foundation Health Plan, Inc. Available at: kpihp.org/blog/housing-first-is-a-matter-of-health/#:~:text=Beginning%20in%202019%2C%20Kaiser%20Permanente%20funded%20a%20series,515%20homeless%20older%20adult%20residents%20in%20Oakland%2C%20California. Accessed October 14, 2024.
[33] Tsai J, Szymkowiak D, Beydoun H, Dasilva L. Transportation As A determinant of health: evaluating the Veterans Affairs rideshare program for homeless patients. Health Aff (Millwood) 2024;43(8):1090–9.