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### Authors

Garcia, Cheyenne

Schrier, Elizabeth

Carey, Caitlin

et al.

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# Sleep Quality among Homeless-Experienced Older Adults: Exploratory Results from the HOPE HOME Study



Cheyenne M. Garcia, BA<sup>1,2</sup>, Elizabeth F. Schrier, BA<sup>3</sup>, Caitlin Carey, PhD<sup>1,2</sup>, Karen A. Valle, MSc<sup>1,2</sup>, Jennifer L. Evans, MS<sup>1,2</sup>, and Margot Kushel, MD<sup>1,2</sup> 

<sup>1</sup>Center for Vulnerable Populations, Zuckerberg San Francisco General Hospital and Trauma Center, University of California, San Francisco, San Francisco, CA, USA; <sup>2</sup>UCSF Benioff Homelessness and Housing Initiative, University of California, San Francisco, San Francisco, CA, USA; <sup>3</sup>School of Medicine, University of California, San Francisco, San Francisco, CA, USA

## ABSTRACT

**BACKGROUND:** Sleep is essential to health and affected by environmental and clinical factors. There is limited longitudinal research examining sleep quality in homeless older adults.

**OBJECTIVE:** To examine the factors associated with poor sleep quality in a cohort of older adults in Oakland, California recruited while homeless using venue-based sampling and followed regardless of housing status.

**DESIGN:** Longitudinal cohort study.

**PARTICIPANTS:** 244 homeless-experienced adults aged  $\geq 50$  from the Health Outcomes in People Experiencing Homelessness in Older Middle Age (HOPE HOME) cohort.

**MAIN MEASURES:** We assessed sleep quality using the Pittsburgh Sleep Quality Index (PSQI). We captured variables via biannual questionnaires and clinical assessments.

**KEY RESULTS:** Our sample was predominantly men (71.3%), Black (82.8%), and had a median age of 58.0 years old (IQR 54.0, 61.0). Two-thirds of participants (67.2%) reported poor sleep during one or more study visits; sleep duration was the worst rated subdomain. In a multivariable model, having moderate-to-severe depressive symptoms (AOR 2.03, 95% CI 1.40–2.95), trouble remembering (AOR 1.56, 95% CI 1.11–2.19), fair or poor physical health (AOR 1.49, 95% CI 1.07–2.08), two or more chronic health conditions (AOR 1.76, 95% CI 1.18–2.62), any ADL impairment (AOR 1.85, 95% CI 1.36–2.52), and being lonely (AOR 1.55, 95% CI 1.13–2.12) were associated with increased odds of poor sleep quality. Having at least one confidant was associated with decreased odds of poor sleep (AOR 0.56, 95% CI 0.37–0.85). Current housing status was not significantly associated with poor sleep quality.

**CONCLUSIONS:** Homeless-experienced older adults have a high prevalence of poor sleep. We found that participants' physical and mental health was related to poor sleep quality. Poor sleep continued when participants re-entered housing. Access to physical and mental healthcare, caregiving support, and programs that promote community may improve homeless-experienced older adults sleep quality, and therefore, their overall health.

**KEY WORDS:** homeless; sleep; older adult

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## INTRODUCTION

Homelessness is dynamic with individuals moving in and out. Some experience short, isolated episodes while others experience longer ones. Nearly a third of single adults experiencing homelessness are chronically homeless.<sup>1</sup> The homeless population in the United States is aging. Approximately a half of single adults experiencing homelessness are aged 50 and older.<sup>2</sup> Homeless-experienced (currently or recently homeless) adults experience accelerated aging. Homeless adults in their 50's and 60's have a prevalence of geriatric conditions similar to housed adults in their 70's and 80's.<sup>3,4</sup> Therefore, homeless-experienced adults are considered “older” at 50.

Sleep is an essential component of health; chronically poor sleep is associated with morbidity and increased all-cause mortality.<sup>5–7</sup> Several demographic (e.g., age), social (e.g., loneliness), clinical (e.g., depression, substance use), and environmental (e.g., noise) factors impact sleep. Certain clinical factors, including depression, have bidirectional associations with sleep.<sup>8</sup> People experiencing homelessness face environmental barriers to good quality sleep. Those experiencing unsheltered homelessness sleep on hard surfaces and are exposed to inclement weather, noise, and light.<sup>9</sup> People in congregate shelters sleep on cots or mattresses on the floor in crowded spaces with poor temperature control.

Previous studies of sleep in homeless adults used cross-sectional methods to examine aspects of sleep (i.e., duration, insomnia) in younger and mostly sheltered samples.<sup>9–11</sup> These found that homeless adults have shorter sleep duration and a higher prevalence of poor sleep than the general population.<sup>9,10</sup> Substance use, mental health symptoms (i.e., feeling depressed, anxious), and safety concerns were associated with poor sleep quality in younger homeless women.<sup>11</sup>

Older age is associated with poor sleep quality stemming from multifactorial physiologic and psychosocial risk factors of aging (e.g., chronic diseases, social isolation).<sup>12–18</sup> Chronic physical and mental health conditions, substance use disorders, and limited social support are risk factors for

poor sleep; they are more prevalent in homeless populations, compared to non-homeless.<sup>19–21</sup>

In a cohort of homeless-experienced adults aged 50 and older where participants transitioned in and out of homelessness, we used longitudinal exploratory analyses to examine the prevalence of poor sleep quality and its associations with demographic, social, clinical, and environmental factors. We hypothesized that older homeless adults have a higher prevalence of poor sleep compared to older adults in the general community and to younger homeless adults. We hypothesized that clinical risk factors (e.g., functional impairment, depressive symptoms) and environmental risk factors (e.g., homeless versus housed, sheltered versus unsheltered) will be associated with poor sleep quality.

## METHODS

### Participants and Setting

Health Outcomes in People Experiencing Homelessness in Older Middle age (HOPE HOME) is a longitudinal study of physical and mental health, life course events, and functional status among adults aged 50 and older in Oakland, California who were homeless at enrollment.<sup>22</sup> From July 2013 to June 2014, we used venue-based sampling to recruit 350 participants (Wave 1) from five overnight homeless shelters, five low-cost meal programs, one recycling center, and places where unsheltered homeless individuals stayed.<sup>22</sup> We constructed our sampling frame to approximate the source population and randomly selected potential participants at each recruitment site.<sup>22, 23</sup> Between August 2017 and July 2018, we recruited an additional 100 participants (Wave 2) to replace those who died or were lost to follow-up using the same recruitment strategy.

Individuals were eligible if they were 50 years of age or older (53 or older in the Wave 2), homeless at baseline according to the Homeless Emergency Assistance and Rapid Transition to Housing (HEARTH) Act,<sup>24</sup> English-speaking, and able to provide informed consent using a teach-back method.<sup>25</sup> Trained study staff conducted in-depth, structured interviews at baseline and every six months thereafter, with brief monthly check-ins in between. Participants remained in the study regardless of housing status at follow-up. We added detailed sleep questions in 2019. We analyzed data from interviews we conducted every six months between 2019 and February 2022.

We compensated participants \$25 for the screening and baseline interview, \$5 for each monthly check-in, and \$20 for each six-month follow-up interview. The institutional review board of the University of California, San Francisco approved the study. The HOPE HOME Community Advisory Board informed the study throughout the research process.

### Measures

We used demographic information from cohort enrollment. Consistent with GEE methodology, we used data regarding the dependent variable (sleep) and independent variables from each follow-up interview in which they completed the sleep questions.

For the exploratory analysis of factors associated with poor sleep, we conceptualized independent variables as demographic/social, clinical, or environmental factors hypothesized to be associated with overall sleep quality.

### Dependent Variable

**Sleep quality.** To assess self-reported sleep quality over the past month, we administered a modified 10-item Pittsburgh Sleep Quality Index (PSQI) composed of seven subdomains scored on a scale of 0 (“no difficulty”) to 3 (“severe difficulty”).<sup>26</sup> We summed subdomain scores to yield a global PSQI score, with higher scores indicating poorer sleep quality. We dichotomized sleep quality as “good” (global PSQI  $\leq$  5) or “poor” (global PSQI  $\geq$  6), using a validated cutoff.<sup>26</sup> For descriptive purposes, we included scores on each of the sleep subdomains: subjective quality, latency, duration, efficiency [ratio of total sleep time to time in “bed”], sleep disturbance, use of sleep medication, and daytime dysfunction [daytime sleepiness; the inability to stay awake and alert during the major waking periods of the day] (Table 3).

### Independent Variables

**Demographics.** We collected demographic information including age, sex, and race/ethnicity.

#### **Social** Social Support

We asked participants how many close friends or relatives they had in whom they could confide (0 vs  $\geq$  1).<sup>27, 28</sup>

#### **Loneliness**

We used the short UCLA Loneliness Scale, which asked participants how often they felt three different components of subjective loneliness on a scale of 1 (“Hardly Ever”) to 3 (“Often”).<sup>29</sup> We considered someone with a score  $\geq$  6 to be lonely (range: 3–9).<sup>30</sup>

#### **Clinical** Health Status

We assessed self-reported health,<sup>31</sup> categorizing responses as fair or poor versus good, very good or excellent. To assess chronic health conditions, we used National Health Interview Survey (NHIS) questions to assess if a healthcare provider had diagnosed participants with hypertension, lung disease (COPD or asthma), coronary artery disease,

congestive heart failure, arthritis, or liver disease (including hepatitis) or cirrhosis.<sup>32</sup> We assessed urinary incontinence during the previous six months by asking participants how often they leaked urine.<sup>33</sup> To assess functional status, we asked participants if they had difficulty performing any of the five activities of daily living (ADLs).<sup>34</sup> We measured if participants had difficulty performing any of the six instrumental activities of daily living (IADLs) using the Brief Instrumental Functioning Scale (BIFS), which has been validated in homeless populations.<sup>35</sup> We dichotomized both variables as zero versus  $\geq 1$  difficulties. To evaluate cognitive impairment, we used the Modified Mini-Mental State Examination (3MS).<sup>36</sup> We defined cognitive impairment as a score below the 7th percentile (i.e., 1.5 standard deviations below a reference cohort mean) or inability to complete the assessment. To evaluate traumatic brain injury (TBI) over the lifetime, we asked participants whether they had ever experienced a head injury resulting in loss of consciousness or hospitalization.<sup>37</sup>

#### *Mental Health*

We adapted mental health questions from the Addiction Severity Index (ASI) to assess whether participants had experienced severe anxiety in the prior 30 days or had hallucinations or trouble remembering in the past six months.<sup>38</sup> We defined moderate-to-severe depressive symptoms as scores  $\geq 22$  on the Center for Epidemiologic Studies Depression Scale (CES-D).<sup>39, 40</sup> Consistent with previous literature, we considered a score of  $\geq 4$  on the Primary Care Post-Traumatic Stress Disorder (PC-PTSD) Screen to indicate PTSD.<sup>41</sup>

#### *Substance Use*

We used questions from the California Tobacco Survey to classify participants as current smokers.<sup>42</sup> We administered the Alcohol Use Disorders Identification Test (AUDIT) to assess severity of alcohol use symptoms in the previous six months and used a validated score of  $\geq 8$  to indicate problematic usage.<sup>43, 44</sup> We used the World Health Organization's Alcohol, Smoking and Substance Involvement Screening Test (WHO-ASSIST) to assess participants' use of cannabis, cocaine, amphetamines, and heroin/non-prescribed opioids in the past six months.<sup>45</sup> We classified scores of  $\geq 4$  for any illicit drug as problematic use.

#### *Environmental Residential History*

For descriptive purposes, we used a follow-back residential calendar to describe participants' self-reported living environments over the previous six months.<sup>46</sup>

#### *Duration of Adult Homelessness*

We calculated the total number of years participants had spent homeless since age 18.

#### *Housing Status*

We considered participants homeless at the time of their first sleep interview (starting in 2019) if they met federal HEARTH criteria for homelessness.<sup>24</sup> We categorized housing status in the 14 days prior to each sleep interview into three categories: homeless, housed/not homeless, and living in a skilled nursing facility (SNF). We defined homeless as staying outdoors, in a place not meant for human habitation, an emergency shelter, or staying in housing where participants needed to leave within two weeks without another place to go.<sup>24</sup> Since we hypothesized that living inside a non-congregate building would be associated with better sleep quality, we classified those staying long-term ( $> 2$  weeks) in transitional housing or private hotels rooms in the housed/not homeless group.

#### *Shelter status*

We asked participants whether they experienced unsheltered homelessness (i.e., sleeping in a place not meant for human habitation, such as cars, parks, sidewalks, abandoned buildings) in the previous six months and calculated the number of nights they reported spending unsheltered. We asked participants whether they stayed any nights at a homeless shelter in the previous six months and calculated the number of nights they did so.

#### *Victimization*

We asked participants if they had experienced 1) physical or sexual abuse or 2) robbery or theft in the prior six months and created two corresponding variables.<sup>47</sup>

## **Analysis**

Our primary dependent variable was poor sleep quality (PSQI score  $\geq 6$ ). We assessed univariable associations between sleep quality at any complete sleep interview and a priori independent variables from baseline (for time constant) or the same completed sleep interview (for time varying) using Chi-squared tests and t-tests. For multivariable analyses, we clustered participants by ID to account for repeated measures with robust Huber–White cluster-adjusted standard errors. We report odds ratios resulting from a GEE analysis with a binomial distribution and a logit link and an unstructured covariance structure. We performed all analyses with SAS version 9.4.<sup>48</sup> We evaluated the association between selected independent variables and poor sleep quality using the GENMOD procedure in SAS. We included both fixed and time-varying covariates in the adjusted analysis if they were significant at the 0.2 level in the bivariate analysis or selected *a priori* based on the literature. Then, we reduced the model using backward elimination retaining variables with  $p$  values  $< .05$  in the final model. Missing data were minimal (i.e.,  $< 5\%$ ) for all outcomes and independent variables with the following exceptions: one person was missing self-rated health and four people were missing loneliness scores. We omitted person-visits with missing data using listwise deletion for each analysis, depending on the included variables. Our primary model examined the relationship

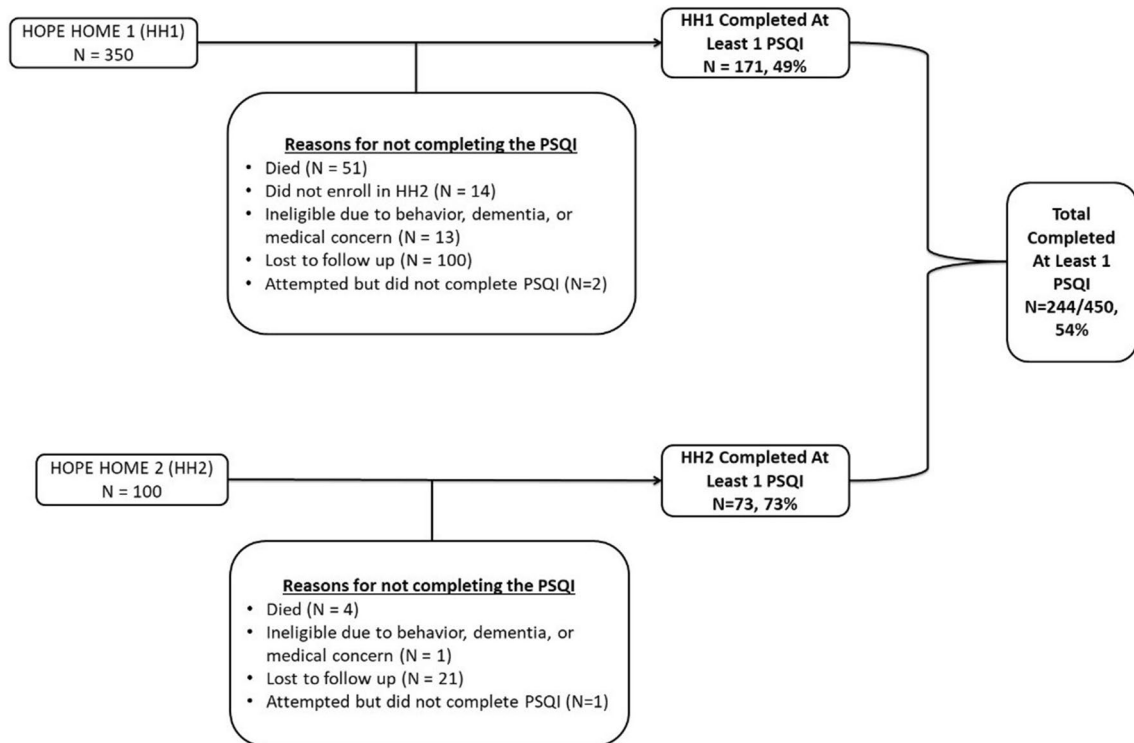


Figure 1 Recruitment of HOPE HOME Sample. Two-hundred and forty-four participants completed at least one sleep interview.

between select variables and the odds of poor sleep quality. We completed an additional analysis to examine the relationship between types of homelessness (sheltered vs. unsheltered) and odds of poor sleep quality.

**RESULTS**

**Sample Characteristics**

This multivariable analysis includes 947 distinct observations from 244 participants who completed at least one sleep interview (range: 1–7). (Figs. 1 and 2) Our participants were predominantly men (71.3%), Black (82.8%), and had a median age of 58.0 years old (IQR 54.0, 61.0) (Table 1).

Approximately half of the sample described their health as fair or poor. Several (43.0%) reported difficulty performing at least one Activity of Daily Living (ADL). Forty percent met the HEARTH criteria for homelessness at the time of their first sleep interview. In the six months prior to their first sleep interview, 38.5% spent at least one night unsheltered ( $M_{\text{nights}} = 50.0$ , SD 72.5) and 17.2% spent at least one night in a shelter ( $M_{\text{nights}} = 12.8$ , SD 38.6) (Table 1). The median duration of follow-up for the cohort was 6.8 years (IQR: 4.0, 7.9).

**Poor Sleep Quality Prevalence**

Approximately two-thirds of the sample (67.2%) met criteria for poor sleep quality at their first sleep interview

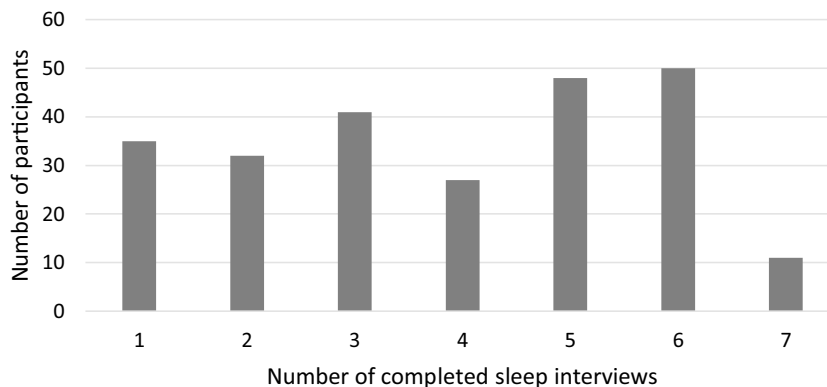


Figure 2 Frequency of sleep interviews among HOPE HOME participants (n = 244).

**Table 1 Characteristics of Homeless-Experienced Older Adults According to Sleep Quality (n = 244)**

Characteristic	Total N/Median (%/IQR)	Good sleep quality (N = 80) N/Median (%/IQR)	Poor sleep quality (N = 164) <sup>a</sup> N/Median (%/IQR)	p-value
<b>Demographics</b>				
Age, in years	58.0 (54.0, 61.0)	59.0 (54.0, 61.0)	58.0 (55.0, 61.0)	0.97
Male	174 (71.3%)	61 (76.3%)	113 (68.9%)	0.23
Black	202 (82.8%)	71 (88.8%)	131 (79.9%)	0.08
<b>Social Support</b>				
≥ 1 confidant	188 (77.0%)	66 (82.5%)	122 (74.4%)	0.16
<b>Loneliness</b>				
Lonely <sup>b</sup>	83 (34.0%)	16 (20.0%)	67 (40.9%)	0.001
<b>Health Status</b>				
Self-reported fair/poor health <sup>c</sup>	120 (49.2%)	30 (37.5%)	90 (54.9%)	0.009
<b>Chronic Conditions<sup>d</sup></b>				
Hypertension	167 (68.4%)	53 (66.3%)	114 (69.5%)	0.61
Lung disease <sup>e</sup>	96 (39.3%)	23 (28.8%)	73 (44.5%)	0.02
Coronary artery disease	17 (7.0%)	5 (6.3%)	12 (7.3%)	0.76
Congestive heart failure	38 (15.6%)	15 (18.8%)	23 (14.0%)	0.34
Arthritis	149 (61.1%)	45 (56.3%)	104 (63.4%)	0.28
Liver disease or cirrhosis	69 (28.3%)	19 (23.8%)	50 (30.5%)	0.27
Urinary incontinence <sup>f</sup>	103 (42.2%)	25 (31.3%)	78 (47.6%)	0.01
ADL impairment <sup>g</sup>	105 (43.0%)	17 (21.3%)	88 (53.7%)	<0.001
IADL impairment <sup>h</sup>	69 (28.3%)	12 (15.0%)	57 (34.8%)	0.001
Cognitive impairment <sup>i</sup>	20 (8.2%)	6 (7.5%)	14 (8.5%)	0.64
Traumatic Brain Injury <sup>k</sup>	11 (4.5%)	1 (1.3%)	10 (6.1%)	0.09
<b>Mental Health</b>				
Anxiety, past 30 days	81 (33.2%)	13 (16.3%)	68 (41.5%)	<0.001
Moderate to severe depressive symptoms, past week <sup>j</sup>	48 (19.7%)	3 (3.8%)	45 (27.4%)	<0.001
Hallucinations, past six months	20 (8.2%)	3 (3.8%)	17 (10.4%)	0.08
Trouble remembering, past six months	65 (26.6%)	8 (10.0%)	57 (34.8%)	<0.001
PTSD symptoms <sup>l</sup>	47 (19%)	7 (8.8%)	40 (24.4%)	0.004
<b>Problematic Substance Use<sup>l</sup></b>				
Current smoker	166 (68.0%)	49 (61.3%)	117 (71.3%)	0.11
Alcohol	31 (12.7%)	7 (8.8%)	24 (14.6%)	0.20
Cannabis	114 (46.7%)	35 (43.8%)	79 (48.2%)	0.57
Cocaine	51 (20.9%)	16 (20.0%)	35 (21.3%)	0.83
Amphetamines	22 (9.0%)	3 (3.8%)	19 (11.6%)	0.04
Heroin and non-prescribed opioids	10 (4.1%)	4 (5.0%)	6 (3.7%)	0.63
<b>Residential History, past 6 months</b>				
Unsheltered (any nights) <sup>m</sup>	94 (38.5%)	24 (30.0%)	70 (42.7%)	0.06
Homeless shelter (any nights)	42 (17.2%)	12 (15.0%)	30 (18.3%)	0.52
<b>Duration of Adult Homelessness</b>				
Duration of adult homelessness in years, median (range)	5.0 (9.2)	3.6 (9.2)	5.0 (9.6)	0.49
<b>Housing Status</b>				
Homeless at time of interview <sup>m</sup>	97 (39.8%)	28 (35.0%)	69 (42.1%)	0.29
<b>Victimization, past 6 months</b>				
Physical or Sexual Abuse	33 (13.5%)	7 (8.8%)	26 (15.9%)	0.13
Robbery/Theft	68 (27.9%)	16 (20.0%)	52 (31.7%)	0.06

P-values are based on Chi-squared tests for categorical variables and t-tests for continuous variables

<sup>a</sup>Pittsburgh Sleep Quality Index ≥ 6

<sup>b</sup>Score of ≥ 6 on the 3-item UCLA Loneliness Scale

<sup>c</sup>Self-rated using Ware et al. 1-item health screen

<sup>d</sup>Self-report of ever receiving diagnosis from a physician

<sup>e</sup>Defined as chronic obstructive pulmonary disease (COPD) or asthma diagnosis

<sup>f</sup>Defined as “leaked urine, even a small amount” in the past 6 months

<sup>g</sup>Self-reported difficulty performing one or more ADLs

<sup>h</sup>Self-reported difficulty performing one or more IADLs as assessed by the Brief Instrumental Functioning Scale

<sup>i</sup>Defined as a score below the 7<sup>th</sup> percentile OR unable to complete the Modified Mini-Mental State Examination (3MS)

<sup>j</sup>Center for Epidemiologic Studies Depression Scale score ≥ 22, Primary Care PTSD Screen score ≥ 3

<sup>k</sup>Defined as head trauma resulting in loss of consciousness or hospitalization

<sup>l</sup>Alcohol Use Disorders Identification Test (AUDIT) score ≥ 8 for alcohol, Alcohol Smoking Substance Involvement Screening Test (ASSIST) score ≥ 4 for illicit drugs, California Tobacco Survey for smoking

<sup>m</sup>Defined as sleeping in a place not meant for human habitation, such as cars, parks, sidewalks, abandoned buildings (on the street)



**Table 2 Median PSQI Scores Overall and by Housing Status at First Interview and Each Sleep Observation**

	Median PSQI Score (IQR)
<b>First Sleep Interview</b>	
All Participants (N=244)	7.0 (3.0–10.0)
Housing Status At Time of First Interview	
Homeless (N=95)	7.0 (4.0–9.0)
Housed/Not Homeless (N=147)	7.0 (3.0–10.0)
Skilled Nursing Facility (N=2)	9.0 (7.0–11.0)
Overall	
All Observations (N=947)	7.0 (4.0–10.0)
Housing Status At Time of Sleep Observation	
Homeless (N=280)	6.0 (3.0–9.0)
Housed/Not Homeless (N=660)	6.0 (3.0–10.0)
Skilled Nursing Facility (N=7)	7.0 (6.0–11.0)

(Table 1). The median PSQI score was 7.0 (range: 0.0–20.0, IQR 3.0, 10.0) (Table 2). Forty-two percent (42.2) of people with poor sleep scores met the HEARTH criteria for homelessness at the time of their first sleep interview (Table 2).

Among participants, the worst sleep scores occurred in the duration (M 1.6, SD 1.3), efficiency (M 1.1, SD 1.2), and latency (M 1.1, SD 1.0) subdomains (Table 3). Participants with poor sleep quality scored worse across all sleep subdomains compared with participants with good sleep quality ( $p < 0.001$ ) (Table 3). On average, people with poor sleep reported mild-to-moderate problems across all sleep subdomains with worst scores in duration (M 2.1, SD 1.1), efficiency (M 1.5, SD 1.2) and latency (M 1.4, SD 1.1).

### Factors Associated with Poor Sleep Quality

In a multivariable model, having moderate-to-severe depressive symptoms (AOR 2.03, 95% CI 1.40–2.95), trouble remembering (AOR 1.56, 95% CI 1.11–2.19), fair or poor physical health (AOR 1.49, 95% CI 1.07–2.08), two or more chronic health conditions (AOR 1.76, 95% CI 1.18–2.62), an ADL impairment (AOR 1.85, 95% CI 1.36–2.52), and being lonely (AOR 1.55, 95% CI 1.13–2.12) were associated with increased odds of poor sleep quality (Table 4). Having at least one confidant was associated with decreased odds of poor

sleep (AOR 0.56, 95% CI 0.37–0.85). In the final multivariable model, we did not find an association between housing status (i.e., being homeless or living in a SNF, compared to being housed) or substance use (alcohol or drug use) and poor sleep quality. In additional analyses, we found that unsheltered homelessness (compared to sheltered homelessness) was not associated with poor sleep quality (Supplemental Table 1). We did not find evidence of multicollinearity.

### DISCUSSION

In this exploratory study of adults with a median age of 58 who were homeless at study enrollment, we found that participants had higher prevalence of poor sleep and worse PSQI scores than in studies of housed adults 20 years older.<sup>49, 50</sup> In our study, two-thirds reported poor sleep quality, compared to 44% of men and 53% of women aged 70 and older in the general population.<sup>49, 50</sup> Our participants had higher prevalence of poor sleep than similarly aged adults in the general population, where 41% of men with a median age of 55 and 50% of women with a median age of 59 had poor sleep quality.<sup>51, 52</sup> While aging is associated with worse outcomes in nearly every sleep subdomain, our findings support that age-related decrements in sleep quality occur at an earlier age in homeless adults.<sup>14</sup> This may be due

**Table 3 Sleep Quality in Homeless-Experienced Older Adults at their First Sleep Interview**

Sleep Subdomain <sup>a</sup>	Total (N=244) Mean (SD)	Good sleep quality (N=80) Mean (SD)	Poor sleep quality <sup>b</sup> (N=164) Mean (SD)	p-value
Subjective sleep quality	1.0 (0.8)	0.5 (0.5)	1.2 (0.8)	<0.001
Sleep latency	1.1 (1.0)	0.4 (0.5)	1.4 (1.1)	<0.001
Sleep duration	1.6 (1.3)	0.7 (0.9)	2.1 (1.1)	<0.001
Sleep efficiency	1.1 (1.2)	0.4 (0.7)	1.5 (1.2)	<0.001
Sleep disturbance	1.0 (0.8)	0.4 (0.5)	1.3 (0.7)	<0.001
Use of sleep medication	0.8 (1.3)	0.1 (0.5)	1.1 (1.4)	<0.001
Daytime dysfunction	0.8 (1.0)	0.3 (0.5)	1.0 (1.1)	<0.001

<sup>a</sup>Each subdomain is scored 0–3 (higher = worse sleep quality)

<sup>b</sup>Poor sleep defined as Pittsburgh Sleep Quality Index score  $\geq 6$

**Table 4** Multivariate Models of Factors Associated with Poor Sleep Quality<sup>a</sup>

Characteristic	Unadjusted odds ratio for poor sleep quality OR (95% CI)	Adjusted odds ratio for poor sleep quality AOR (95% CI)
Demographics		
Male	0.83 (0.53–1.30)	
Age	1.01 (0.97 – 1.06)	
Black race	<b>0.54 (0.30–0.99)</b>	
Social Support		
≥ 1 confidant	<b>0.60 (0.41 – 0.88)</b>	<b>0.56 (0.37 – 0.85)</b>
Loneliness		
Lonely <sup>b</sup>	<b>1.87 (1.41–2.49)</b>	<b>1.55 (1.13 – 2.12)</b>
Health Status		
Fair/poor health <sup>c</sup>	<b>1.84 (1.37–2.48)</b>	<b>1.49 (1.07 – 2.08)</b>
Two or more chronic conditions <sup>d</sup>	<b>2.09 (1.42 – 3.09)</b>	<b>1.76 (1.18 – 2.62)</b>
Lung disease <sup>d,e</sup>	<b>1.85 (1.25 – 2.76)</b>	
Urinary incontinence <sup>f</sup>	<b>1.53 (1.11–2.10)</b>	
ADL impairment <sup>g</sup>	<b>2.45 (1.85–3.24)</b>	<b>1.85 (1.36 – 2.52)</b>
IADL impairment <sup>h</sup>	<b>1.49 (1.11–2.00)</b>	
Mental Health		
Anxiety, past 30 days	<b>1.90 (1.42–2.54)</b>	
Moderate to severe depressive symptoms, past week <sup>j</sup>	<b>2.84 (2.07–3.91)</b>	<b>2.03 (1.40 – 2.95)</b>
Hallucinations in the past six months <sup>i</sup>	<b>1.68 (1.20 – 2.36)</b>	
Trouble remembering in the past six months	<b>2.06 (1.57 – 2.71)</b>	<b>1.56 (1.11 – 2.19)</b>
Positive PTSD screen <sup>l</sup>	<b>1.99 (1.42- 2.79)</b>	
Traumatic Brain Injury <sup>k</sup>	<b>4.75 (1.15–19.60)</b>	
Problematic Substance Use <sup>l</sup>		
Alcohol	<b>1.82 (1.18 – 2.80)</b>	
Amphetamines	1.03 (1.00 – 1.06)	
Housing Status At Time of Interview		
Housed/Not Homeless	Referent	
Homeless	<b>1.42 (0.98–2.07)</b>	
Skilled Nursing Facility	<b>1.60 (0.29–8.88)</b>	
Victimization, past 6 months		
Robbery/Theft	<b>1.70 (1.17 – 2.47)</b>	

We included independent variables with univariable *P*-values of  $\leq 0.20$  in a multivariable model and used backwards elimination to reduce the model, retaining variables with  $P \leq 0.05$  (bolded) in the final model

<sup>a</sup>Poor sleep quality defined as Pittsburgh Sleep Quality Index  $\geq 6$

<sup>b</sup>Defined as a score of  $\geq 6$  on the 3-item UCLA Loneliness Scale

<sup>c</sup>Self-rated using Ware et al. 1-item health screen

<sup>d</sup>Self-report of ever receiving diagnosis from a physician

<sup>e</sup>Defined as chronic obstructive pulmonary disease (COPD) or asthma diagnosis

<sup>f</sup>Defined as “leaked urine, even a small amount” in the past 6 months

<sup>g</sup>Self-reported difficulty performing one or more ADLs

<sup>h</sup>Self-reported difficulty performing one or more IADLs as assessed by the Brief Instrumental Functioning Scale

<sup>i</sup>Defined as a score below the 7<sup>th</sup> percentile OR unable to complete the Modified Mini-Mental State Examination (3MS)

<sup>j</sup>Center for Epidemiologic Studies Depression Scale score  $\geq 22$ , yes to ASI question about hallucinations in prior six months, Primary Care PTSD Screen score  $\geq 3$

<sup>k</sup>Defined as head trauma resulting in loss of consciousness or hospitalization

<sup>l</sup>Alcohol Smoking Substance Involvement Screening Test (ASSIST) score  $\geq 4$ , Alcohol Use Disorders Identification Test (AUDIT) score  $\geq 8$

to co-morbid conditions prevalent in older homeless adults and associated with poor sleep, such as ADL impairments and depression or due to the difficult environmental conditions of homelessness.<sup>3, 53, 54</sup>

Fair or poor self-reported health, multiple chronic diseases, poor functional status (ADL impairments), mental and cognitive health (depressive symptoms and trouble remembering) were associated with increased odds of poor

sleep quality. Poor health status and chronic diseases are risk factors for poor sleep.<sup>6, 13, 16, 55, 56</sup> There is an established bidirectional relationship between poor sleep quality and depression.<sup>18, 57–60</sup> Poor sleep may be a prodromal symptom of depression, people who are predisposed to poor sleep may also be predisposed to depression, or poor sleep may alter cognition and emotional regulation, thus increasing depression risk.<sup>56</sup> ADL impairments, a measure of functional



status, could signal functional decline, which corresponds to worsening sleep, or poor sleep could lead to functional decline.<sup>61–66</sup>

Similar to previous research, we found that social support was a protective factor for sleep quality.<sup>17, 67</sup> This may be due to evolutionary reasons; individuals with social support may feel safer and sleep better.<sup>20, 68</sup> Loneliness was associated with increased odds of poor sleep, supporting prior research.<sup>58–60, 69</sup> Stress, associated with feeling lonely and experiencing homelessness, may mediate this relationship.<sup>70, 71</sup>

We did not find an association between ongoing homelessness (as opposed to regaining housing) or substance use and poor sleep quality. Decrements in sleep quality associated with homelessness may be lasting.<sup>10, 72</sup> We posit some explanations for this. Some regained housing but remained in overcrowded situations with inadequate bedding, suggesting ongoing environmental impacts on sleep. Others continued to experience anxiety related to housing stability, which may contribute to ongoing poor sleep.<sup>20, 73, 74</sup> The lack of association between problematic alcohol or substance use and poor sleep contradicts findings in the general population.<sup>75–77</sup> This may be due to the high prevalence of problematic substance use or other causes of poor sleep.

Participants reported the most impairments in sleep duration, while the general older population report worst scores in sleep disturbances.<sup>49, 50</sup> This may relate to the environmental conditions of homelessness which limit access to sleep, including noise and light pollution, hypervigilance of threats to safety, lack of convenient restrooms, exposure to cold and rain, and mandatory early awakenings in shelters. These environmental challenges appear to negatively affect sleep in both sheltered and unsheltered environments.

Our study has several limitations. We conducted our study in one city, which limits generalizability. It is possible that poor sleep quality causes or worsens the associated physical and mental health conditions, that these conditions cause poor sleep, or that the relationship is bidirectional. We measured symptoms of mental health problems (i.e., depressive symptoms) not clinical diagnoses (i.e., depression).<sup>53, 78</sup> However, our study used validated scales (e.g., CES-D) for all variables.<sup>40, 79</sup> Finally, this study was exploratory and reports multiple adjusted effects in the same model, which may limit interpretative validity. Some strengths of our study included our use of longitudinal data, our inclusion of measures of overall sleep quality, examining sleep in a variety of housing situations, and our focus on older adults, a group at high risk of poor sleep.

Homeless-experienced older adults have a high prevalence of poor sleep quality. Ongoing lack of quality sleep, even after regaining housing, is an underappreciated negative impact of homelessness among older adults. Poor sleep

may contribute to the overall poor health status of people experiencing homelessness. Access to physical and mental healthcare, caregiving support, and programs that promote social connection may improve homeless-experienced older adults' sleep quality and overall health. Preventing homelessness may protect against potentially long-lasting poor-quality sleep.

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**Corresponding Author:** Margot Kushel, MD; Center for Vulnerable Populations, Zuckerberg San Francisco General Hospital and Trauma Center, University of California, San Francisco, San Francisco, CA, USA (e-mail: [margot.kushel@ucsf.edu](mailto:margot.kushel@ucsf.edu)).

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