HHS Public Access

Author manuscript

*Soc Sci Med*. Author manuscript; available in PMC 2020 February 15.

Published in final edited form as:

*Soc Sci Med*. 2019 December ; 242: 112585. doi:10.1016/j.socscimed.2019.112585.

# Association between Homelessness and Opioid Overdose and Opioid-related Hospital Admissions/Emergency Department Visits

**Ayae Yamamoto, SM**[1], **Jack Needleman, PhD**[1], **Lillian Gelberg, MD, MSPH**[1,2,3], **Gerald Kominski, PhD**[1,4], **Steven Shoptaw, PhD**[2,5], **Yusuke Tsugawa, MD, MPH, PhD**[4,6]

[1]Department of Health Policy and Management, UCLA Fielding School of Public Health, 650, Charles Young Drive South, 31-269 CHS, Los Angeles, CA 90095, USA

[2]Department of Family Medicine, David Geffen School of Medicine at UCLA, 10880 Wilshire, Blvd, Suite 1800, Los Angeles, CA 90024, USA

[3]Office of Healthcare Transformation and Innovation, VA Greater Los Angeles Healthcare, System, 11301 Wilshire Blvd, Los Angeles, CA 90073, USA

[4]UCLA Center for Health Policy Research, 10960 Wilshire Blvd, Suite 1550, Los Angeles, CA, 90024, USA

[5]Department of Psychiatry and Biobehavioral Sciences, David Geffen School of Medicine at, UCLA, 760 Westwood Plaza, Los Angeles, CA 90095, USA

[6]Division of General Internal Medicine and Health Services Research, David Geffen School of Medicine at UCLA, 1100 Glendon Avenue, Los Angeles, CA 90024, USA

## Abstract

**Background:** Although homelessness and opioid overdose are major public health issues in the U.S., evidence is limited as to whether homelessness is associated with an increased risk of opioid overdose.

**Objective:** To compare opioid-related outcomes between homeless versus housed individuals in low-income communities.

**Corresponding author:** Ayae Yamamoto, SM, PhD Candidate, Department of Health Policy and Management, UCLA Fielding School of Public Health, Address: 650 Charles Young Dr. S., 31-269 CHS Box 951772, Los Angeles, CA 90095, Phone: +1-510-565-6267, ayaey5@gmail.com.

**Contributors:** YT obtained funding. AY obtained data and ethics approval. All authors, contributed to the study design, analysis, interpretation of the results; and preparation, review, and approval of the manuscript. AY is the guarantor. The corresponding author attests that all, listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

**Competing interests:** All authors have completed the ICMJE uniform disclosure form at www.icjme.org/coi_disclosure.pdf

**Ethical approval:** The study was approved by the institutional review board at UCLA

**Data sharing:** No additional data available

**Transparency:** AY affirms that the manuscript is an honest, accurate, and transparent account of, the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

**Design, Setting, and Participants:** Cross-sectional analysis of individuals who had at least one ED visit or hospitalization in four states (Florida, Maryland, Massachusetts, and New York) in 2014.

**Measurements:** Risk of opioid overdose and opioid-related ED visits/hospital admissions were compared between homeless versus low-income housed individuals, adjusting for patient characteristics and hospital-specific fixed effects (effectively comparing homeless versus low-income housed individuals treated at the same hospital). We also examined whether risk of opioid-related outcomes varied by patients' sex and race/ethnicity.

**Results:** A total of 96,099 homeless and 2,869,230 low-income housed individuals were analyzed. Homeless individuals had significantly higher risk of opioid overdose (adjusted risk, 1.8% for homeless vs. 0.3% for low-income housed individuals; adjusted risk difference [aRD], +1.5%; 95%CI, +1.0% to +2.0%; p<0.001) and opioid-related ED visit/hospital admission (10.4% vs. 1.5%; aRD, +8.9%; 95%CI, +7.2% to +10.6%; p<0.001) compared to low-income housed individuals. Non-Hispanic White females had the highest risk among the homeless population, whereas non-Hispanic White males had the highest risk among the low-income housed population.

**Limitations:** Individuals with no ED visit or hospitalization in 2014 were not included.

**Conclusion:** Homeless individuals had disproportionately higher adjusted risk of opioid-related outcomes compared to low-income housed individuals treated at the same hospital. Among homeless individuals, non-Hispanic White females incurred the highest risk. These findings highlight the importance of recognizing the homeless population—especially White female homeless population—as a high-risk population for opioid overdose.

### Keywords

opioid overdose; opioid abuse; homeless; homelessness; emergency department

## INTRODUCTION

The opioid overdose epidemic has become one of the most important public health emergencies in the United States. Opioid overdose was responsible for an estimated 50,000 deaths in 2017 (1), and its total economic burden is estimated to be over $500 billion annually (2). Studies have found that life expectancy in the United States declined in 2017 for the third consecutive year, in part, due to an increase in deaths from unintentional injuries, including opioid overdoses (3). Despite a number of efforts targeted at reducing the number of adverse events from opioid overdose, the effectiveness of such strategies has been limited.

Homelessness is another major public health issue in the United States, with an estimated 2.5 to 3.5 million Americans experiencing homelessness annually (4), and over 550,000 people are homeless on any given night (5, 6). Homeless individuals experience higher chronic and acute disease burdens (7, 8); higher mortality rates (9, 10); and are more likely to utilize costly emergency department and hospital inpatient services compared to housed individuals (7, 11, 12). Although these two public health problems are closely related, they are often addressed separately. Given the lack of access to healthcare and social support

available to the homeless population, they may be incurring a higher burden of opioid use disorders compared to a comparable low-income housed population.

Evidence is scarce as to whether homelessness is associated with an increased risk of opioid-related adverse health outcomes. Existing studies suggest that homeless individuals are at a higher risk of opioid overdose than the general population (9, 13). However, these studies are limited as they were conducted in a single city or hospital (in Boston or New York City) (9, 13), or among Veterans (14, 15) and therefore, it remains largely unknown whether these findings are generalizable to other cities, states and non-Veterans. To our knowledge, no study to date has examined the association between homelessness and opioid-related health outcomes using multi-state data, possibly due to the lack of data that can reliably identify the homeless population. Although chronic pain guidelines recommend physicians to co-prescribe naloxone (a life-saving opioid antagonist) to patients who have a high risk for opioid overdose (16), accurate prediction models for opioid overdose have not yet been developed. Furthermore, existing prediction models do not include homeless status as a key predictor (17–36). It is, thus, critical for clinicians to accurately identify patients with a high risk of opioid overdose, employ targeted screening, and to intervene if necessary, to effectively address the current opioid overdose epidemic.

In this context, we used datasets that include all hospital admissions and emergency department (ED) visits from four large and diverse states to examine the association between homelessness and opioid overdose and the use of emergent care for opioid use among patients who had an ED visit(s) or hospitalization(s) in 2014. The comparison group consisted of housed individuals living in low-income neighborhoods (defined by zip code with the lowest median household income quartile), which we refer to as “low-income housed”. To identify patient populations with the highest risk, we also investigated patient’s sex and race/ethnicity associated with the highest risk of opioid-related adverse health outcomes among the homeless population and low-income housed individuals, separately.

## METHODS

### Data Sources and Study Sample

We analyzed the 2014 State Inpatient Database (SID) and the State Emergency Department Databases (SEDD) for four states (Florida, Maryland, Massachusetts, and New York), that are made available for the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality (37). The SID includes all inpatient discharge records from community hospitals (including emergency visits that result in hospitalization), and the SEDD includes all emergency department (ED) visits at hospital-affiliated emergency departments that do not lead to a subsequent hospitalization. These databases capture visit information for all patients regardless of the type of insurance and insurance status. The records for each patient include a direct report of homeless status, key demographic information such as age, gender and race, insured status, and data on the primary diagnosis associated with the visit and secondary diagnoses that affect the course or cost of treatment. The non-public use data sets we used also include a unique patient linkage number that allows us to track patients across multiple visits and admissions, allowing a direct assessment of the frequency of use and variations in diagnosis across visits. We used data

from four states with homeless flags to achieve the broadest range of socioeconomic and geographic diversity in the study (only 7 states [4 states included in our analysis plus Georgia, Utah and Wisconsin] reported both the homeless indicator and a unique patient linkage number for both SID and SEDD in 2014. Our internal investigation found a severe underreporting of the homeless indicator for Utah and Wisconsin's SID/SEDD, and the hospital identifier was not available in Georgia's SID/SEDD; therefore, these states were not included in our analyses), and homeless status is reported directly from the hospitals (38). For each inpatient and hospital-affiliated emergency department discharge, there is an indicator for each patient's homeless status, which has been used in previous studies (39–44).

The study population was restricted to individuals aged ≥18 years old with at least one ED visit or hospital admission in 2014. We compared individuals who were identified as homeless with housed individuals living in the lowest income quartile (median household income was estimated based on residential zip code). We excluded people with a primary diagnosis related to delivery (Clinical Classification Software single-level codes: 177–192, 194–196, 218–220, 222–224) since a significant proportion of inpatient visits were delivery-related (6.1% [398,475/513,409] of all visits), and people with missing data on the homeless indicator (0.6% of individuals in our data were missing information about the homeless indicator) or any of the key adjustment variables described below.

## Outcome variables

The primary outcomes were: (1) opioid overdose and (2) opioid-related ED visit or hospital admission. Opioid overdose was defined as having any of the following ICD-9 diagnosis codes: 965.00 – 965.02, 965.09, E850.0 - E850.2 in the first 10 diagnosis codes across all ED visits or hospital admissions (45). Opioid-related ED visit or hospital admission was identified using the following ICD-9 codes: 304.00 – 304.02, 304.70 – 304.72, 305.50 – 305.52, 965.00 – 965.02, 965.09, 970.1, E850.0 - E850.2, E935.0 – E935.2, E940.1 (46).

## Adjustment variables

We adjusted for patient characteristics and hospital-specific fixed effects. Patient characteristics included age (categorized as 18–34, 35–44, 45–55 and 65+ years old), sex, race, and ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, and other), primary insurance type (Medicare, Medicaid, private, self-pay, and no charge/other), and 26 comorbidities included in the Elixhauser Comorbidities Index (47) (excluding drug abuse). We also adjusted for hospital-specific fixed effects (indicator variables for each hospital) to account for both measured and unmeasured characteristics of hospitals that do not vary over time (48). Therefore, our models effectively compared homeless and low-income housed individuals treated at the same hospital.

## Statistical analysis

First, we examined the association between homeless status and opioid overdose and opioid-related ED visits/hospitalizations using multivariable regression models. We used multivariable linear probability models with Huber-White robust standard errors to account for heteroscedasticity (because small cell sizes for some combinations of patient

characteristics resulted in complete or quasi-complete separation in logistic regression models (49)), adjusting for patient characteristics (age, sex, race/ethnicity, primary payer, Elixhauser co-morbidities) and hospital-specific fixed effects. After fitting the regression models, adjusted outcomes were calculated using the marginal standardization form of predictive margins (also known as predictive margins or margins of responses); for each individual we calculated predicted probabilities of opioid-related outcomes with homeless indicator fixed at each category (0 or 1) and then averaged over the distribution of covariates in our sample (50).

Then, we examined patients' sex and race/ethnicity associated with the highest risk of opioid-related adverse health outcomes among the homeless population and the low-income population with housing, respectively. In doing so, we estimated the adjusted risk of opioid-related adverse health outcomes (adjusted for patient characteristics and hospital-specific fixed effects) for each combination of patients' sex and race/ethnicity.

### Secondary analyses

We conducted several sensitivity analyses. To determine whether the lower than expected count of homeless individuals in FL and MD could influence our results, we restricted our sample to MA and NY. Next, we restricted the analysis only to male patients and conducted a separate analysis only for ED visits because low-income housed individuals may be more likely present to hospitals for pregnancy-related concerns or elective surgeries. Finally, since residual confounding may bias our results, we performed a formal test to assess the sensitivity of unmeasured confounders to regression results (51).

All analyses were conducted in SAS Enterprise Guide 4.2 (SAS Institute) and Stata, version 14 (StataCorp). This study was approved by the institutional review board of the University of California, Los Angeles Office of the Human Research Protection Program.

## RESULTS

Our final sample consists of 96,099 homeless and 2,869,230 low-income housed individuals who had at least one ED visit/hospital admission in 2014 in these four states. Compared to low-income housed individuals, homeless individuals were slightly older, more likely to be male, more likely to be have Medicaid as primary payer, more likely to be Hispanic or other race/ethnicity, and more likely to have comorbidities such as alcohol and drug abuse, mental illness, and diabetes (Table 1).

### Association between homelessness and opioid-related adverse health outcomes

After adjusting for patient characteristics and hospital-specific fixed effects (effectively comparing homeless versus low-income housed individuals treated at the same hospital), homeless individuals had significantly higher risk of opioid overdose (adjusted risk, 1.8% for homeless vs. 0.3% for low-income housed individuals; adjusted risk difference [aRD], 1.5%; 95%CI, 1.0% to 2.0%; $p<0.001$) and opioid-related ED visit/hospital admissions (adjusted risk, 10.4% vs. 1.5%; aRD, 8.9%; 95%CI, 7.2% to 10.6%; $p<0.001$) compared to low-income housed individuals (Table 2).

### Identifying the highest risk sex and race/ethnicity subgroup

We found that, among the homeless population, non-Hispanic White females experienced the highest risk of opioid overdose (Figure 1 and Online Appendix Tables A and B). On the other hand, among low-income housed individuals, non-Hispanic White males had the highest risk. We found a similar pattern for opioid-related ED visits and hospitalizations (Figure 2 and Online Appendix Tables A and B).

### Secondary analyses

Overall, our findings for both opioid outcomes were not sensitive to restricting the analysis to NY and MA (Online Appendix Table 2A), to male patients (Online Appendix Table 3A), or to patients with ED visits only (Online Appendix Table 4A). Homeless individuals, on average, had greater number of ED and inpatient visits per person compared to low-income housed individuals (Online Appendix Table 5A). The test to assess the sensitivity of our regression results to unmeasured confounders revealed that residual confounding is unlikely to explain the observed association between homeless status and the two opioid outcomes (Online Appendix Table 6A).

## DISCUSSION

Using a comprehensive dataset of all ED visits and hospital admissions from four large and diverse states, we found homeless persons had significantly higher risk of opioid overdose and opioid-related ED visits/hospital admissions, even when they were compared to low-income housed individuals who were treated at the same hospital. We also found that non-Hispanic White females incurred the largest risk of opioid-related adverse health outcomes among the homeless population, whereas non-Hispanic White males incurred the highest risk among the low-income housed population. These findings suggest that homelessness is an issue that extends beyond poverty—as homeless individuals are at higher risks even compared to comparable, low-income individuals with housing—and shed light on the importance of homeless individuals, especially non-Hispanic White female homeless individuals, as the high-risk population of the opioid overdose.

Although chronic pain guidelines currently recommend that physicians co-prescribe naloxone, a life-saving opioid antagonist, to patient at high risk of opioid overdose (16), clinical tools to effectively identifying patients who could benefit from naloxone are lacking. A recent study using machine-learning algorithms to predict patients with high risk of opioid overdose identified 268 potential predictors of opioid overdose, but the homelessness was not included as one of the potential predictors (27). Indeed, homelessness has not been identified as an important predictor of opioid overdose in the currently-available clinical prediction models. Our findings, indicating a higher risk of opioid-related outcomes among the homeless population, underscore the importance of including homelessness as the key predictor in the clinical tools for predicting patients at an increased risk of opioid overdose.

There are several potential mechanisms that could explain our findings. First, it is possible that homeless people may use opioids as a way to cope with their emotional suffering and distress from living on the streets (52, 53). Alternatively, it is also possible that addiction to

opioids makes people more likely to become homeless due to their limited ability to work, strained relationships with family and friends, and challenges in accessing and motivation for receiving treatment for their addiction (53–55). We tried to isolate the impact of homelessness by using low-income individuals with housing as the control, and our findings suggest that homelessness *per se*—after controlling for the impact of poverty—is an independent risk factor for opioid-related adverse health outcomes. Second, in addition to their higher risks of opioid overdose, homeless individuals may also face a major barrier to accessing any drug treatment (56), and once treatment is completed, they confront additional barriers transitioning to life without opioids. Even for homeless persons who complete treatment programs, overdose risks may remain high when they leave that treatment as they lapse to opioid use on the streets (57). These increased risks for overdose observed in our study may be linked with a lower tolerance and the lack of access to any treatments for opioid addiction, but especially medication-assisted treatments (58). Moreover, not all community health centers provide medication-assisted treatments, and among those that do, the majority of the clinics face provider shortages (59).

We also found that the highest risk population subgroup for opioid overdose was different for homeless compared to low-income housed individuals, and to our knowledge, this is the first to study race-sex combinations for opioid-related emergency and hospitalization risk. Non-Hispanic White females incurred the highest risk among the homeless population, whereas non-Hispanic White males exhibited the highest risk among the low-income housed population. These findings are consistent with a recent report using a nationally-representative sample of Medical Expenditure Panel Study (MEPS) that found that women were more likely than men to have had any opioid use as well as frequent opioid use during the year (60). Another study using national survey data found that non-Hispanic White females may be slightly more likely to receive prescription opioids compared to non-Hispanic White males (61). The differences in risks based on sex and race/ethnicity may be explained, in part, by differences in cultural perspectives on pain, access to pain treatment, and/or provider bias between non-Hispanic White persons and racial and ethnic minorities (62–64).

To our knowledge, this is the first study using data from multiple states to show that homeless individuals experience higher risk of opioid-related adverse health outcomes in emergent care settings. Existing studies that assessed the relationship between homelessness and opioid overdose are limited as they are conducted using a convenient sample collected in a single city or hospital (mostly in Boston and New York City) (9, 13) or among Veterans (14, 15). The SID/SEDD database from 4 states used in this study contains all ED visits and hospital admissions, and covers more than 10% of the US population and 17% of the homeless population, according to estimates from the U.S. Department of Housing and Urban Development (5). We are unaware of any other databases that allow detailed analysis of the healthcare needs and use of a broad and representative sample of the homeless population.

Our findings are consistent with previous smaller studies suggesting that homeless individuals may have higher opioid misuse compared to housed individuals (13, 65). A study conducted in Boston found that a third of the deaths for homeless individuals younger than

45 years were associated with a drug overdose, and opioids were implicated in 81% of all overdose deaths (9). A recent interview conducted by a public New York City emergency department showed that homeless patients had higher risk of heroin and prescription opioid use compared with housed patients (13).

Our findings suggest that the homeless population, and in particular White female homeless population, is at a higher risk of opioid overdose. While it has been recognized that opioid use may be higher among homeless individuals, evidence has been limited. For clinicians, identifying homelessness as an important predictor of opioid overdose would allow them to refer patients to appropriate care and precautions, and to co-prescribe naloxone if necessary. Our findings demonstrating high levels of opioid use among homeless patients, its association with an increased risk of opioid overdose, and non-Hispanic White female homeless individuals having the highest risk of opioid overdose, should be informative for policymakers and frontline clinicians to recognize the high-risk population of opioid overdose, employ more targeted screening, and use interventions (such as co-prescription of naloxone) that can more effectively reduce opioid overdose at the population level.

Our study has limitations. First, as is the case with any cross-sectional studies, the temporal relationship between exposure and outcome could not be assessed. Therefore, we are not able to rule out the possibility of reverse causation. It is possible that opioid addiction may lead individuals to lose employment and become homeless or hinder their efforts to get off the streets rather than homeless status causing higher risk of opioid overdose.

Second, exposure and outcome misclassification is another limitation. For instance, homelessness is a dynamic status and we are not able to capture the severity of homelessness (i.e., chronic versus temporary homeless) in our data. If temporary homeless individuals are coded as homeless, it will only bias the effect towards the null. Furthermore, when homeless counts were compared with the Housing and Urban Development's 2014 point-in-time estimates, they appeared undercounted for MD and FL. However, sensitivity analysis restricted to NY and MA confirmed that our findings did not qualitatively change based on this restriction (Online Appendix Table 2A). This may be due to individuals being under-coded for these states or that homeless individuals are not being admitted to the ED or hospital. If homeless status was collected based on a self-report, the homeless count may be underreported due to social desirability bias. Homeless status in our data, however, is collected by hospitals, and hospitals have strong financial incentives associated with billing and collection to accurately determine where the patient lives. Nevertheless, some patients may underreport to the hospitals that they are homeless and/or are living in homelessness because of fear of stigma and discrimination, or because they do not consider themselves to be homeless.

Third, although we used low-income housed individuals as the control in order to isolate the impact of homelessness from poverty, our control group may not be perfect. In our data, the lowest quartile of household income was $1-$39,999 in 2014, which includes individuals with a substantially higher income than homeless individuals. However, the use of a control group in our study is more robust than existing studies evaluating the impact of homelessness by comparing their health outcomes with the general population (without

restricting to a low-income population). Fourth, the SID/SEDD database captures only individuals who had at least one ED visit or hospital admission in 2014, and therefore, our findings may not be generalizable to healthier or sicker homeless individuals who had no encounter with ED or hospitals in a given year. Further, it is possible that housed individuals with opioid use disorders are getting treated in non-emergent care settings and thus, we are not able to compare the risk of opioid-use disorders between the two groups. Lastly, although we used all ED visits and hospital discharge data from four large and diverse states, our findings may not be generalizable to homeless patients in states not included in our analysis.

In summary, among homeless and low-income housed individuals who sought care in inpatient and emergency departments in 2014, homeless individuals experienced significantly higher risk of opioid overdose and opioid-related ED visits/hospitalizations, even compared to low-income housed individuals treated at the same hospital. Among the homeless population, non-Hispanic White females exhibited the highest risk of opioid-related adverse health outcomes, whereas non-Hispanic White males experienced the highest risk among the low-income housed population. Our findings highlight the importance of recognizing the homeless population—especially the non-Hispanic White female homeless population—as a high-risk population for opioid overdose. EDs and hospitals may be able to help address this epidemic by screening homeless individuals for opioid use disorders and have a system in place to refer these patients to community clinics for medication-assisted treatment. Additional research is warranted to understand the specific characteristics of individuals, geography, and health and social policy—such as policies on providing “housing for health,” access to substance use treatment and health care, case management for individuals discharging from treatments to address risks for relapse during transitions, and care when opioid prescribing—that may contribute to excessive opioid dependence and overdose deaths among homeless persons.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgments

**Funding source:** St. Luke’s International University (Tokyo, Japan).

## References

1. National Institute on Drug Abuse. Overdose Death Rates. National Institute of Health; 2018.
2. Council of Economic Advisors. The Underestimated Cost of the Opioid Crisis. In: Executive Office of the President, ed; 2017.
3. Dyer O US life expectancy falls for third year in a row. Bmj. 2018;363:k5118. [PubMed: 30514705]
4. National Coalition for the Homeless. How Many People Experience Homelessness. Washington D.C: National Coalition for the Homeless; 2009.
5. The US Department of Housing and Urban Development. The 2017 Annual Homeless Assessment Report (AHAR) to Congress. In: US Department of Housing and Urban Development, ed. Washington D.C; 2017.

6. Fazel S, Geddes JR, Kushel M. The health of homeless people in high-income countries: descriptive epidemiology, health consequences, and clinical and policy recommendations. Lancet. 2014;384(9953):1529–40. [PubMed: 25390578]
7. Bharel M, Lin WC, Zhang J, O'Connell E, Taube R, Clark RE. Health care utilization patterns of homeless individuals in Boston: preparing for Medicaid expansion under the Affordable Care Act. Am J Public Health. 2013;103 Suppl 2:S311–7. [PubMed: 24148046]
8. Institute of Medicine Committee on Health Care for Homeless People. Homelessness, Health, and Human Needs. Washington (DC): National Academies Press (US) 1988.
9. Baggett TP, Hwang SW, O'Connell JJ, Porneala BC, Stringfellow EJ, Orav EJ, et al. Mortality among homeless adults in Boston: shifts in causes of death over a 15-year period. JAMA Intern Med 2013;173(3):189–95. [PubMed: 23318302]
10. Hibbs JR, Benner L, Klugman L, Spencer R, Macchia I, Mellinger A, et al. Mortality in a cohort of homeless adults in Philadelphia. N Engl J Med 1994;331(5):304–9. [PubMed: 8022442]
11. Kushel MB, Perry S, Bangsberg D, Clark R, Moss AR. Emergency department use among the homeless and marginally housed: results from a community-based study. Am J Public Health. 2002;92(5):778–84. [PubMed: 11988447]
12. Kushel MB, Vittinghoff E, Haas JS. Factors associated with the health care utilization of homeless persons. Jama. 2001;285(2):200–6. [PubMed: 11176814]
13. Doran KM, Rahai N, McCormack RP, Milian J, Shelley D, Rotrosen J, et al. Substance use and homelessness among emergency department patients. Drug Alcohol Depend. 2018;188:328–33. [PubMed: 29852450]
14. Iheanacho T, Stefanovics E, Rosenheck R. Opioid use disorder and homelessness in the Veterans Health Administration: The challenge of multimorbidity. J Opioid Manag 2018;14(3):171–82. [PubMed: 30044482]
15. Midboe AM, Byrne T, Smelson D, Jasuja G, McInnes K, Troszak LK. The Opioid Epidemic In Veterans Who Were Homeless Or Unstably Housed. Health Aff (Millwood). 2019;38(8):1289–97. [PubMed: 31381401]
16. Dowell D, Haegerich TM, Chou R. CDC Guideline for Prescribing Opioids for Chronic Pain - United States, 2016. MMWR Recomm Rep 2016;65(1):1–49.
17. Becker WC, Sullivan LE, Tetrault JM, Desai RA, Fiellin DA. Non-medical use, abuse and dependence on prescription opioids among U.S. adults: psychiatric, medical and substance use correlates. Drug Alcohol Depend 2008;94(1–3):38–47. [PubMed: 18063321]
18. Bohnert AS, Valenstein M, Bair MJ, Ganoczy D, McCarthy JF, Ilgen MA, et al. Association between opioid prescribing patterns and opioid overdose-related deaths. Jama. 2011;305(13): 1315–21. [PubMed: 21467284]
19. Cepeda MS, Fife D, Chow W, Mastrogiovanni G, Henderson SC. Assessing opioid shopping behaviour: a large cohort study from a medication dispensing database in the US. Drug Saf 2012;35(4):325–34. [PubMed: 22339505]
20. Cochran G, Gordon AJ, Lo-Ciganic WH, Gellad WF, Frazier W, Lobo C, et al. An Examination of Claims-based Predictors of Overdose from a Large Medicaid Program. Med Care. 2017;55(3): 291–8. [PubMed: 27984346]
21. Dunn KM, Saunders KW, Rutter CM, Banta-Green CJ, Merrill JO, Sullivan MD, et al. Opioid prescriptions for chronic pain and overdose: a cohort study. Ann Intern Med 2010;152(2):85–92. [PubMed: 20083827]
22. Glanz JM, Narwaney KJ, Mueller SR, Gardner EM, Calcaterra SL, Xu S, et al. Prediction Model for Two-Year Risk of Opioid Overdose Among Patients Prescribed Chronic Opioid Therapy. J Gen Intern Med 2018;33(10):1646–53. [PubMed: 29380216]
23. Gwira Baumblatt JA, Wiedeman C, Dunn JR, Schaffner W, Paulozzi LJ, Jones TF. High-risk use by patients prescribed opioids for pain and its role in overdose deaths. JAMA Intern Med 2014;174(5):796–801. [PubMed: 24589873]
24. Hall AJ, Logan JE, Toblin RL, Kaplan JA, Kraner JC, Bixler D, et al. Patterns of abuse among unintentional pharmaceutical overdose fatalities. Jama. 2008;300(22):2613–20. [PubMed: 19066381]

25. Hylan TR, Von Korff M, Saunders K, Masters E, Palmer RE, Carrell D, et al. Automated prediction of risk for problem opioid use in a primary care setting. J Pain. 2015;16(4):380–7. [PubMed: 25640294]
26. Ives TJ, Chelminski PR, Hammett-Stabler CA, Malone RM, Perhac JS, Potisek NM, et al. Predictors of opioid misuse in patients with chronic pain: a prospective cohort study. BMC Health Serv Res 2006;6:46. [PubMed: 16595013]
27. Lo-Ciganic WH, Huang JL, Zhang HH, Weiss JC, Wu Y, Kwoh CK, et al. Evaluation of Machine-Learning Algorithms for Predicting Opioid Overdose Risk Among Medicare Beneficiaries With Opioid Prescriptions. JAMA Netw Open. 2019;2(3):e190968.
28. Oliva EM, Bowe T, Tavakoli S, Martins S, Lewis ET, Paik M, et al. Development and applications of the Veterans Health Administration's Stratification Tool for Opioid Risk Mitigation (STORM) to improve opioid safety and prevent overdose and suicide. Psychol Serv 2017;14(1):34–49. [PubMed: 28134555]
29. Rice JB, White AG, Birnbaum HG, Schiller M, Brown DA, Roland CL. A model to identify patients at risk for prescription opioid abuse, dependence, and misuse. Pain Med 2012;13(9):1162–73. [PubMed: 22845054]
30. Rose AJ, Bernson D, Chui KKH, Land T, Walley AY, LaRochelle MR, et al. Potentially Inappropriate Opioid Prescribing, Overdose, and Mortality in Massachusetts, 2011–2015. J Gen Intern Med 2018;33(9):1512–9. [PubMed: 29948815]
31. Sullivan MD, Edlund MJ, Fan MY, Devries A, Brennan Braden J, Martin BC. Risks for possible and probable opioid misuse among recipients of chronic opioid therapy in commercial and medicaid insurance plans: The TROUP Study. Pain. 2010;150(2):332–9. [PubMed: 20554392]
32. Webster LR, Cochella S, Dasgupta N, Fakata KL, Fine PG, Fishman SM, et al. An analysis of the root causes for opioid-related overdose deaths in the United States. Pain Med 2011;12 Suppl 2:S26–35. [PubMed: 21668754]
33. Webster LR, Webster RM. Predicting aberrant behaviors in opioid-treated patients: preliminary validation of the Opioid Risk Tool. Pain Med 2005;6(6):432–42. [PubMed: 16336480]
34. White AG, Birnbaum HG, Schiller M, Tang J, Katz NP. Analytic models to identify patients at risk for prescription opioid abuse. Am J Manag Care. 2009;15(12):897–906. [PubMed: 20001171]
35. Zedler B, Xie L, Wang L, Joyce A, Vick C, Brigham J, et al. Development of a Risk Index for Serious Prescription Opioid-Induced Respiratory Depression or Overdose in Veterans' Health Administration Patients. Pain Med 2015;16(8):1566–79. [PubMed: 26077738]
36. Zedler BK, Saunders WB, Joyce AR, Vick CC, Murrelle EL. Validation of a Screening Risk Index for Serious Prescription Opioid-Induced Respiratory Depression or Overdose in a US Commercial Health Plan Claims Database. Pain Med 2018;19(1):68–78. [PubMed: 28340046]
37. Healthcare Cost and Utilization Project (HCUP) 2018;Pages. Accessed at Agency for Healthcare Research and Quality at https://www.hcup-us.ahrq.gov/databases.jsp on 7/11 2018.
38. Healthcare Cost and Utilization Project (HCUP) 2008;Pages. Accessed at Agency for Healthcare Research and Quality at https://www.hcup-us.ahrq.gov/db/vars/sedddistnote.jsp?var=homeless on 09/07/2018 2018.
39. Karaca Z, Wong HS, Mutter RL. Characteristics of Homeless and Non-Homeless Individuals Using Inpatient and Emergency Department Services, 2008: Statistical Brief #152 Healthcare Cost and Utilization Project (HCUP) Statistical Briefs. Rockville (MD): Agency for Healthcare Research and Quality (US); 2013.
40. Sun R, Karaca Z, Wong HS. Characteristics of Homeless Individuals Using Emergency Department Services in 2014: Statistical Brief #229 Healthcare Cost and Utilization Project (HCUP) Statistical Briefs. Rockville (MD): Agency for Healthcare Research and Quality (US); 2006.
41. Manzano-Nunez R, Zogg CK, Bhulani N, McCarty JC, Herrera-Escobar JP, Lu K, et al. Association of Medicaid Expansion Policy with Outcomes in Homeless Patients Requiring Emergency General Surgery. World J Surg 2019;43(6):1483–9. [PubMed: 30706104]
42. Rosendale N, Guterman EL, Betjemann JP, Josephson SA, Douglas VC. Hospital admission and readmission among homeless patients with neurologic disease. Neurology 2019;92(24):e2822-e31.

43. White B, Ellis C, Jones W, Moran W, Simpson K. The effect of the global financial crisis on preventable hospitalizations among the homeless in New York State. J Health Serv Res Policy. 2018;23(2):80–6. [PubMed: 29320892]
44. White BM, Ellis C Jr., Simpson KN Preventable hospital admissions among the homeless in California: a retrospective analysis of care for ambulatory care sensitive conditions. BMC Health Serv Res 2014;14:511. [PubMed: 25344441]
45. Larochelle MR, Zhang F, Ross-Degnan D, Wharam JF. Rates of opioid dispensing and overdose after introduction of abuse-deterrent extended-release oxycodone and withdrawal of propoxyphene. JAMA Intern Med 2015;175(6):978–87. [PubMed: 25895077]
46. Weiss AJ, Heslin KC. Payers of Opioid-Related Inpatient Stays and Emergency Department Visits Nationally and by State, 2010 and 2015: Statistical Brief #239 Healthcare Cost and Utilization Project (HCUP) Statistical Briefs. Rockville (MD): Agency for Healthcare Research and Quality (US); 2006.
47. Healthcare Cost and Utilization Project (HCUP) 2017;Pages. Accessed at Agency for Healthcare Research and Quality, at https://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp on 7/11/2018 2018.
48. Fizmaurice G, Laird N, Ware J. Applied Longitudinal Analysis, 2nd Edition: John Wiley & Sons; 2011.
49. Hellevik O Linear versus logistic regression when the dependent variable is a dichotomy. Quality & Quantity. 2009;43(1):59–74.
50. Williams R Using the margins command to estimate and interpret adjusted predictions and marginal effects. The Stata Journal. 2012;12(2):308–31.
51. Lin DY, Psaty BM, Kronmal RA. Assessing the sensitivity of regression results to unmeasured confounders in observational studies. Biometrics. 1998;54(3):948–63. [PubMed: 9750244]
52. Didenko E, Pankratz N. Substance Use: Pathways to homelessness? Or a way of adapting to street life? Visions Journal. 2007;4(1):9–10.
53. National Coalition for the Homeless. Substance Abuse and Homelessness. Washington, D.Cc: National Coalition for the Homeless; 2017.
54. Chatterjee A, Yu EJ, Tishberg L. Exploring opioid use disorder, its impact, and treatment among individuals experiencing homelessness as part of a family. Drug Alcohol Depend 2018;188:161–8. [PubMed: 29778009]
55. Johnson TP, Freels SA, Parsons JA, Vangeest JB. Substance abuse and homelessness: social selection or social adaptation? Addiction. 1997;92(4):437–45. [PubMed: 9177065]
56. Upshur CC, Jenkins D, Weinreb L, Gelberg L, Orvek EA. Homeless women's service use, barriers, and motivation for participating in substance use treatment. Am J Drug Alcohol Abuse. 2018;44(2):252–62. [PubMed: 28806101]
57. Shah NG, Galai N, Celentano DD, Vlahov D, Strathdee SA. Longitudinal predictors of injection cessation and subsequent relapse among a cohort of injection drug users in Baltimore, MD, 1988–2000. Drug Alcohol Depend 2006;83(2):147–56. [PubMed: 16364568]
58. Meges D, Zevin B, Cookson E, Bascelli L, Denning P, Little J, et al. Adapting Your Practice: Recommendations for the Care of Homeless Patients with Opioid Use Disorders. In: Health Care for the Homeless Clinicians' Network NHCft, Homeless Council I, eds. Nashville TN; 2014:102.
59. Zur J, Tolbert J. The Role of Community Health Centers in Addressing the Opioid Epidemic. Kaiser Family Foundation; 2018.
60. Miller GE, Moriya AS. Any Use and Frequent Use of Opioids among Non-Elderly Adults in 2015–2016, by Socioeconomic Characteristics Statistical Brief (Medical Expenditure Panel Survey (US)). Rockville (MD): Agency for Healthcare Research and Quality (US); 2018.
61. Rosenbloom JM, Burns SM, Kim E, August DA, Ortiz VE, Houle TT. Race/Ethnicity and Sex Both Affect Opioid Administration in the Emergency Room. Anesth Analg 2018.
62. Cintron A, Morrison RS. Pain and ethnicity in the United States: A systematic review. J Palliat Med 2006;9(6):1454–73. [PubMed: 17187552]
63. Anderson KO, Green CR, Payne R. Racial and ethnic disparities in pain: causes and consequences of unequal care. J Pain. 2009;10(12):1187–204. [PubMed: 19944378]

64. Hirsh AT, Hollingshead NA, Ashburn-Nardo L, Kroenke K. The interaction of patient race, provider bias, and clinical ambiguity on pain management decisions. J Pain. 2015;16(6):558–68. [PubMed: 25828370]

65. Marshall JR, Gassner SF, Anderson CL, Cooper RJ, Lotfipour S, Chakravarthy B. Socioeconomic and geographical disparities in prescription and illicit opioid-related overdose deaths in Orange County, California, from 2010–2014. Subst Abus. 2018:1–7.

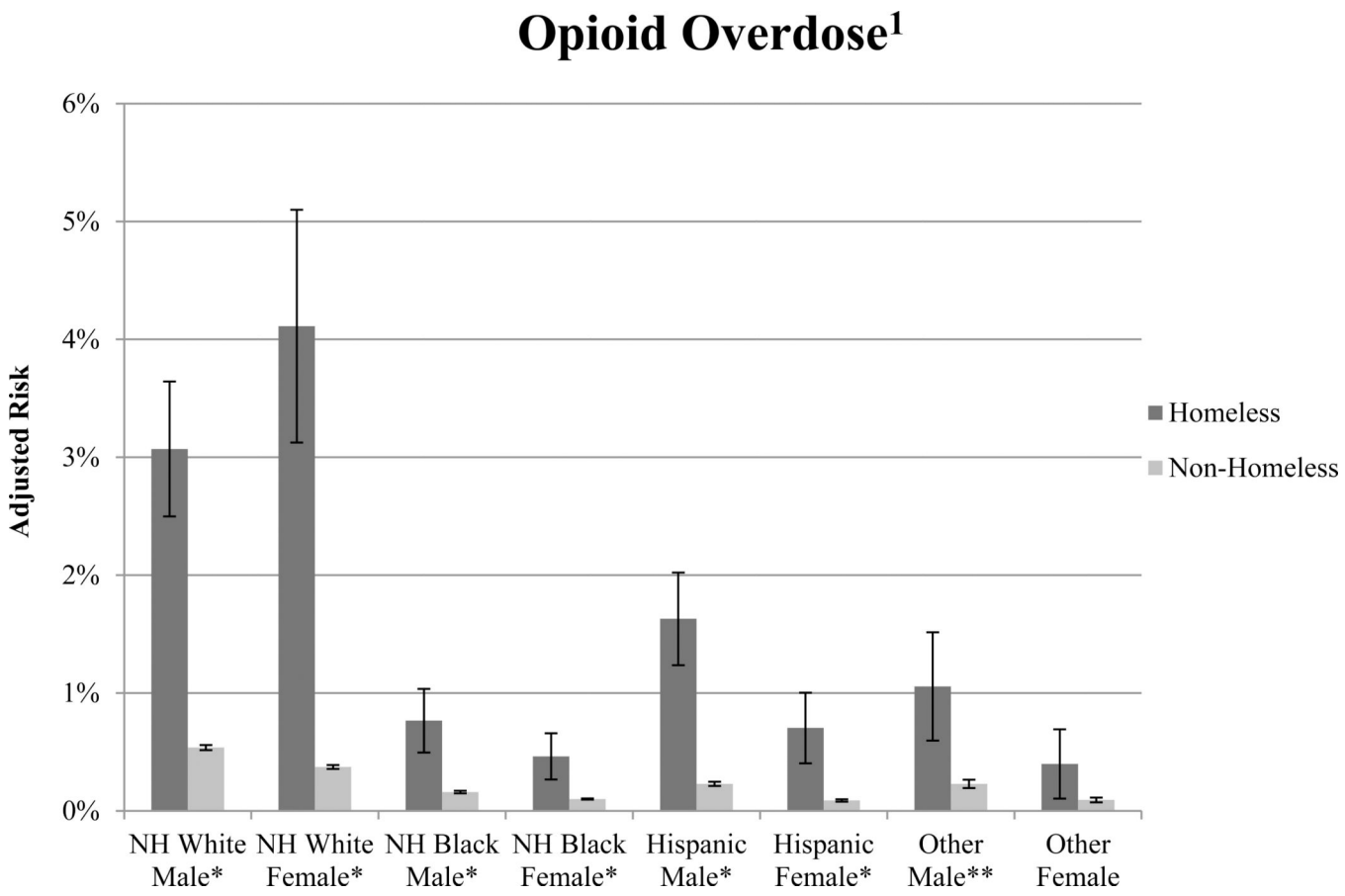


**Figure 1.**

Adjusted risk of opioid overdose for homeless compared to low-income housed patients, by Sex and Race/ethnicity

*NH* = Non-Hispanic

[1] Wald p-value for heterogeneity statistically significant at p<0.001

*Point estimate statistically significant at p<0.001

**Point estimate statistically significant at p<0.002

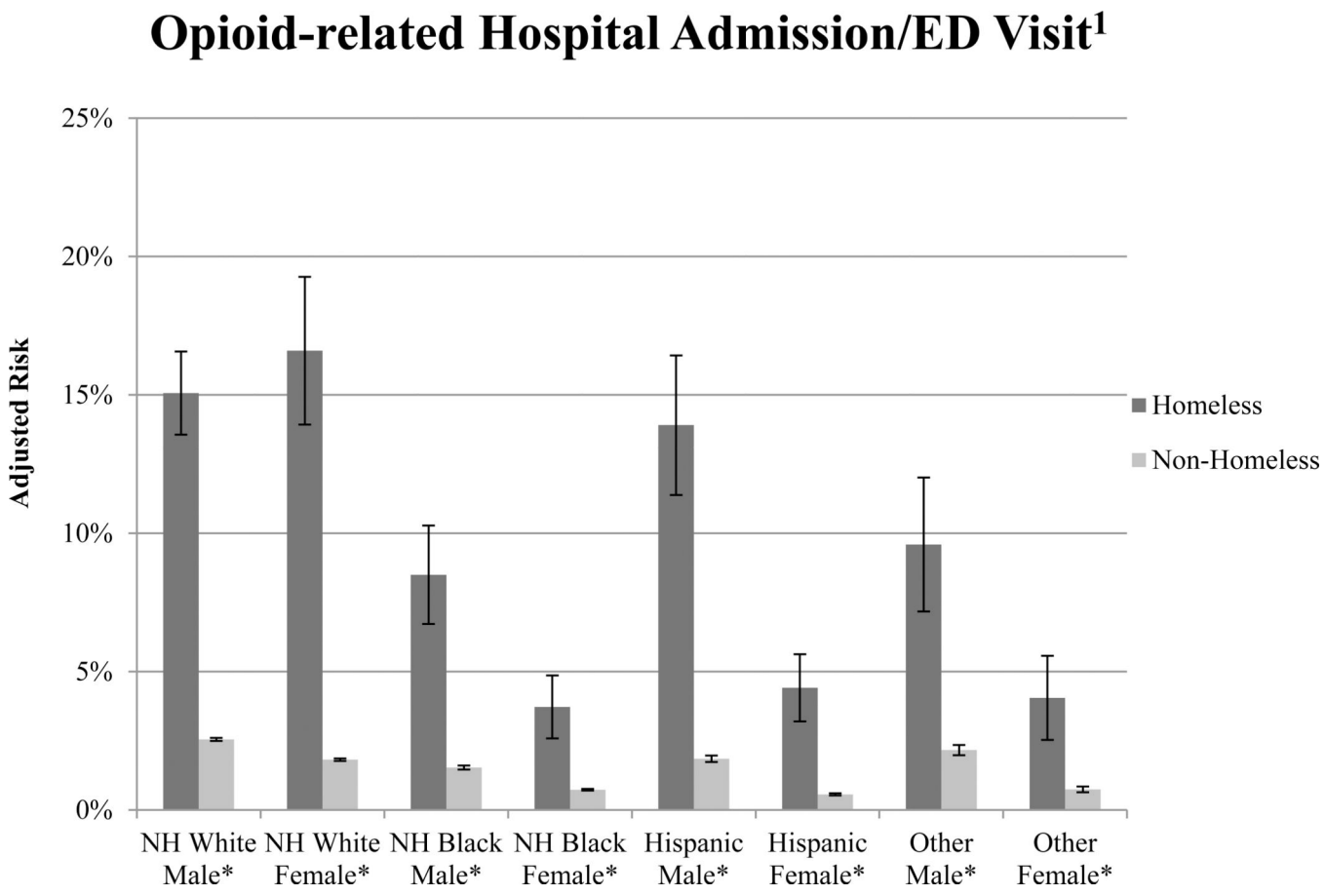


**Figure 2.**

Adjusted risk of opioid-related emergency department (ED) visit/hospital admission for homeless compared to low-income housed patients, by Sex and Race/ethnicity

*NH* = Non-Hispanic

[1] Wald p-value for heterogeneity statistically significant at p<0.001

*Point estimate statistically significant at p<0.001

**Point estimate statistically significant at p<0.002

**Table 1.**

Characteristics of homeless vs. low-income housed individuals

| | Homeless individuals (N=96,099) | Low-income housed individuals (N=2,869,230) | *P* value |
|---|---|---|---|
| **Age in years at admission, mean (SD)** | 47.7 (18.0) | 47.2 (20.0) | <0.0001 |
| **Female** | 42,705 (44.5%) | 1,607,821 (56.3%) | <0.0001 |
| **Primary expected payer** | | | |
| **Medicaid** | 51,018 (53.1%) | 748,567 (26.2%) | |
| **Medicare** | 21,159 (22.0%) | 742,560 (26.0%) | |
| **Private insurance** | 3,803 (4.0%) | 672,970 (23.6%) | <0.0001 |
| **Self-pay** | 15,850 (16.5%) | 538,431 (18.9%) | |
| **No charge/Other** | 4,170 (4.3%) | 152,370 (5.3%) | |
| **Race/ethnicity** | | | |
| **Non-Hispanic White** | 30,021 (31.3%) | 1,160,535 (40.7%) | |
| **Non-Hispanic Black** | 28,990 (30.2%) | 906,190 (31.7%) | <0.0001 |
| **Hispanic** | 23,195 (24.2%) | 595,236 (20.8%) | |
| **Other** | 13,794 (14.4%) | 192,937 (6.8%) | |
| **Selected Elixhauser co-morbidities** | | | |
| **Alcohol abuse** | 7,194 (7.5%) | 44,676 (1.6%) | <0.0001 |
| **Drug abuse** | 8,689 (9.1%) | 46,337 (1.6%) | <0.0001 |
| **Psychoses** | 4,756 (5.0%) | 37,480 (1.3%) | <0.0001 |
| **Depression** | 4,208 (4.4%) | 73,814 (2.6%) | <0.0001 |
| **Congestive heart failure** | 2,492 (2.6%) | 46,598 (1.6%) | <0.0001 |
| **Neurological disorders** | 4,882 (5.1%) | 63,391 (2.2%) | <0.0001 |
| **Chronic pulmonary disease** | 8,567 (8.9%) | 158,387 (5.5%) | <0.0001 |
| **Diabetes** | 13,896 (14.5%) | 223,028 (7.8%) | <0.0001 |
| **Renal failure** | 3,845 (4.0%) | 75,705 (2.7%) | <0.0001 |
| **Cancer** | 1,523 (1.6%) | 26,136 (0.9%) | <0.0001 |

* Low-income housed individuals were defined as individuals who live in areas with the lowest quartile of the median household income.

**Table 2.**

Unadjusted and adjusted opioid-related adverse health outcomes between homeless compared to low-income housed individuals

| | | No. of individuals | Unadjusted outcomes (95% CI) | Adjusted outcomes (95% CI) | Adjusted risk difference (95% CI) | *P* value |
|---|---|---|---|---|---|---|
| **Opioid Overdose** | Homeless | 1,829 | **1.9%** (1.8% to 2.0%) | **1.8%** (1.3% to 2.2%) | **1.5%** (1.0% to 2.0%) | <0.001 |
| | Low-income Housed | 7,170 | **0.3%** (0.3% to 0.3%) | **0.3%** (0.2% to 0.3%) | | |
| **Opioid-related ED Visit/ Hospital Admission** | Homeless | 10,792 | **11.2%** (11.1% to 11.5%) | **10.4%** (8.8% to 12.1%) | **8.9%** (7.2% to 10.6%) | <0.001 |
| | Low-income Housed | 42,797 | **1.5%** (1.5% to 1.5%) | **1.5%** (1.5% to 1.6%) | | |

*Adjusted for patient characteristics and hospital-specific fixed effects. Low-income housed refers to individuals who live in areas with the lowest quartile of the median household income