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Healthcare Use and Outcomes of Homeless Patients: Multi-State Population-Based Analyses

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Healthcare Use and Outcomes of Homeless Patients: Multi-State Population-Based Analyses

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Doctor of Philosophy in Health Policy and Management

by

Ayae Yamamoto

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ABSTRACT OF DISSERTATION

Healthcare Use and Outcomes of Homeless Patients: Multi-State Population-Based Analyses

by

Ayae Yamamoto

Doctor of Philosophy in Health Policy and Management

University of California, Los Angeles, 2020

Professor Jack Needleman, Chair

Homelessness affects millions of Americans each year, and many homeless individuals have complex healthcare needs that place high demands on the United States healthcare system. This dissertation explores adverse health services utilization outcomes of the homeless population using the Healthcare Cost and Utilization Project's 2014 State Inpatient Database and the State Emergency Department Database from Florida, Maryland, Massachusetts, and New York.

The first paper, "Association between homelessness and opioid overdose and opioid-related hospital admissions/emergency department visits," examines opioid overdose and opioid-related hospitalization/emergency department (ED) visit risks of homeless patients compared to a low-income housed comparison group. The study used multivariable linear probability models with hospital fixed effects for dichotomous outcomes. Outcomes were also stratified by sex and race/ethnicity. The study found that homeless patients had substantially higher risks for both outcomes, and the non-Hispanic white female homeless patients were particularly the highest

risk group in this patient population. Implementing screenings for homelessness and opioid abuse may be critical for curbing the opioid epidemic in this population.

The second paper, “Frequent emergency department use among homeless individuals: High risk of opioid-related diagnoses and adverse health services utilization outcomes,” compares opioid outcomes, mechanical ventilation, mortality, and hospitalizations of homeless patients who had 4 or more ED visits, 2-3 ED visits and 1 ED visit in 2014, and identifies predictors for higher rates of ED use. Multivariable linear probability models with hospital fixed effects were used for the main analyses and a negative binomial regression model with hospital fixed effects was used for predicting higher rates of ED use. The study revealed that homeless patients who are high ED users were more likely to be hospitalized and have other adverse outcomes. These findings encourage targeted interventions for the high-utilizer homeless population to reduce the burden of serious outcomes and costs for the patient and society.

The third paper, “Association between homelessness and delivery hospitalization outcomes: a multi-state population-based study,” explores delivery hospitalization outcomes of pregnant homeless versus non-homeless women. This project used inpatient data from FL, MA and NY and overlap propensity-score weighing method and regression adjustment. Compared to non-homeless women treated within the same facility, homeless women had higher likelihoods of experiencing placental abnormalities, preterm labor and higher delivery hospitalization costs. A large majority of homeless women were treated in government-owned safety-net hospitals with lower average delivery costs compared to non-homeless women, who were mainly treated in not-for-profit hospitals. These findings highlight the importance of screening pregnant women for social needs, including homelessness, as well as developing policies that encourage partnerships between healthcare providers and community resources, such as local social housing programs.

Taken together, all three papers highlight the adverse health outcomes of the homeless population and the need to quickly identify homeless patients and refer them to appropriate care.

The dissertation of Ayae Yamamoto is approved.

Lillian Gelberg

Gerald Kominski

Yusuke Tsugawa

Jack Needleman, Committee Chair

University of California, Los Angeles

2020

DEDICATION

I would like to dedicate this dissertation to my parents and my sister, Yoshie, for their unwavering support, love and inspiration.

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2. **Yamamoto, A.,** Harris, H. R., Vitonis, A. F., Chavarro, J. E., & Missmer, S. A. (2018). A prospective cohort study of meat and fish consumption and endometriosis risk. Am J Obstet Gynecol. doi:10.1016/j.ajog.2018.05.034

3. **Yamamoto, A.**, Johnstone, E. B., Bloom, M. S., Huddleston, H. G., & Fujimoto, V. Y. (2017). A higher prevalence of endometriosis among Asian women does not contribute to poorer IVF outcomes. *J Assist Reprod Genet, 34*(6), 765-774. doi:10.1007/s10815-017-0919-1

4. **Yamamoto, A.,** McCormick, M. C., & Burris, H. H. (2015). Disparities in antidepressant use in pregnancy. *J Perinatol, 35*(4), 246-251. doi:10.1038/jp.2014.197

5. **Yamamoto, A.,** McCormick, M. C., & Burris, H. H. (2014). US provider-reported diet and physical activity counseling to pregnant and non-pregnant women of childbearing age during preventive care visits. *Matern Child Health J, 18*(7), 1610-1618. doi:10.1007/s10995-013-1401-z

6. Danforth, K. N., Luong, T. Q., Yi, D. K., **Yamamoto, A.**, Kawatkar, A. A., Kim, P. H., . . . Williams, S. G. (2019). Disparities in Stage at Diagnosis in an Equal-access Integrated Delivery System: A Retrospective Cohort Study of 7244 Patients With Bladder Cancer. *Clin Genitourin Cancer*. doi:10.1016/j.clgc.2019.09.002

7. Danforth KN, Sidell MA, Luong TQ, Yi DK, **Yamamoto A**, Kawatkar AA, et al. Care Quality and Variability in the Use of Intravesical Therapy for Initial Treatment of Nonmuscle Invasive Bladder Cancer Within a Large, Diverse Integrated Delivery System. Urology. 2019;131:93-103.

8. Lewis, K. H., Fischer, H., Ard, J., Barton, L., Bessesen, D. H., Daley, M. F., Desai, J., Fitzpatrick, SL., Horberg, M., Koebnick, C., Oshiro, C., **Yamamoto, A.**, Young, DR., Arterburn, D. E. (2019). Safety and Effectiveness of Longer-Term Phentermine Use: Clinical Outcomes from an Electronic Health Record Cohort. *Obesity (Silver Spring), 27*(4), 591-602. doi:10.1002/oby.22430

9. Young DR, Nguyen MK, **Yamamoto A**, et al. Telephone-based motivational interviewing versus usual care in primary care to increase physical activity: a randomized pilot study. *Pilot and feasibility studies.* 2019;5:6.

10. Young, D. R., Fischer, H., Arterburn, D., Bessesen, D., Cromwell, L., Daley, M. F., . . . **Yamamoto, A**. (2018). Associations of overweight/obesity and socioeconomic status with hypertension prevalence across racial and ethnic groups. *J Clin Hypertens (Greenwich), 20*(3), 532-540. doi:10.1111/jch.13217

11. Fisher, D., Coleman, K. J., Arterburn, D. E., Fischer, H., **Yamamoto, A.**, Young, D. R., . . . Lewis, K. H. (2017). Mental illness in bariatric surgery: A cohort study from the PORTAL network. *Obesity (Silver Spring), 25*(5), 850-856. doi:10.1002/oby.21814

12. Lewis, K. H., Gudzune, K. A., Fischer, H., **Yamamoto, A.**, & Young, D. R. (2016). Racial and ethnic minority patients report different weight-related care experiences than non-Hispanic Whites. *Prev Med Rep, 4*, 296-302. doi:10.1016/j.pmedr.2016.06.015

13. Young, D. R., Waitzfelder, B. A., Arterburn, D., Nichols, G. A., Ferrara, A., Koebnick, C., **Yamamoto, A**., Daley, MF., Sherwood, NE., Cromwell, L., Lewis, K. H. (2016). The Patient Outcomes Research To Advance Learning (PORTAL) Network Adult Overweight and Obesity Cohort: Development and Description. *JMIR Res Protoc, 5*(2), e87. doi:10.2196/resprot.5589

CHAPTER I: INTRODUCTION

An estimated 2.5 to 3.5 million Americans experience homelessness each year (National Coalition for the Homeless, 2009), and over 560,000 people are homeless on any given night (Fazel, Geddes, & Kushel, 2014; U.S. Department of Housing and Urban Development, 2019). Homelessness will likely remain a public health issue for decades to come at the current rate of progress, and thus, a targeted approach to address this public health crisis is deemed necessary.

Past studies have found that homeless individuals have high chronic and acute disease burdens (Bharel et al., 2013; Institute of Medicine Committee on Health Care for Homeless People, 1988) and mortality rates (Baggett et al., 2013; Hibbs et al., 1994), and are less likely to utilize preventive services and more likely to utilize costly emergency department and hospital inpatient services (Bharel et al., 2013; Kushel, Perry, Bangsberg, Clark, & Moss, 2002; Kushel, Vittinghoff, & Haas, 2001). In pregnant women, homelessness has been associated with adverse pregnancy outcomes and complications (Clark, Weinreb, Flahive, & Seifert, 2019; Richards, Merrill, & Baksh, 2011; Stein, Lu, & Gelberg, 2000). However, the extent of this burden to society is less clear. Due to funding and data limitations, many of the landmark homeless studies are from the 1980s, 1990s and early 2000s (Burt et al., 1999; Institute of Medicine Committee on Health Care for Homeless People, 1988; Kushel et al., 2001), and studies conducted in a single city (Baggett et al., 2013; Bharel et al., 2013; Hibbs et al., 1994; Hwang et al., 2013; Hwang, Orav, O'Connell, Lebow, & Brennan, 1997; Padgett, Struening, Andrews, & Pittman, 1995).

In mainstream media, Malcolm Gladwell's 2006 New Yorker article, "Million Dollar Murray," brought the homeless issue to public attention (Gladwell, 2006). Here, he follows the life of Murray Barr, a chronically homeless alcoholic man in Reno, NV, and details Murray's exorbitant hospital bills as well as those of similar folks in other cities. Gladwell explains that homelessness has a power law distribution and argues that there should be more structure and support for those at the tail end of this distribution. Murray Barr is just one example out of tens of thousands of other homeless individuals in the US who have a similar story. In the next few chapters, I hope to delineate who the homeless are and what their burden to society entails.

Evidence is scarce and limited as to the actual impact of homelessness on health, utilization of care, and costs of care. Previous studies that examined the influence of homelessness have been limited by the fact that they were conducted in a small geographic region such as a city (Baggett et al., 2013; Bharel et al., 2013; Hibbs et al., 1994; Hwang et al., 2013; Hwang et al., 1997; Padgett et al., 1995), did not have a valid comparison group (Ku, Scott, Kertesz, & Pitts, 2010; Nielsen, Hjorthoj, Erlangsen, & Nordentoft, 2011; Tadros, Layman, Brewer, & Davis, 2016), were restricted to a high risk subgroup among the homeless (Lim et al., 2018; Vijayaraghavan, Penko, Bangsberg, Miaskowski, & Kushel, 2013), and/or were limited in sample size (Smith et al., 2017; Wagner et al., 2014). There are even fewer studies that examine pregnancy and delivery outcomes of homeless women. Therefore, it remains largely unclear how homelessness affects the health and utilization of patients, and the magnitude of the issues (i.e., emergency visits, hospitalizations, costs), especially at the multi-state level.

1.1 Goals and Objectives

In the following three papers, this dissertation explores relationships between homelessness, homeless patients' healthcare use, and adverse health services utilization outcomes in hospital and emergency department settings.

The first goal of this dissertation is to understand whether homeless patients have higher risks for opioid-related outcomes among those presenting to hospitals and emergency departments

(ED). My objectives are: (1) to compare opioid overdose and opioid-related visit outcomes for homeless compared to low-income housed patients in ED and inpatient facilities in Florida, Maryland, Massachusetts and New York in 2014, and (2) to identify the subgroup of homeless adults who have the highest risk for these outcomes. My hypothesis is that homeless individuals have higher risks of opioid overdose and opioid-related hospital admissions/ED visits because substance abuse and mental illness disproportionally affect a large number of homeless individuals. Further, many homeless individuals often do not have the resources to seek care for substance abuse, which makes them even more vulnerable to untreated and recurrent addiction. This study uses the 2014 State Inpatient and the State Emergency Department Databases and multivariable linear probability models with hospital fixed effects to determine the association between homelessness and opioid-related outcomes, followed by sex-race/ethnicity stratified analyses.

The second goal is to understand differences in health services utilization outcomes among homeless patients who returned to the ED varying numbers of times. My objectives are to: (1) compare health services utilization outcomes (opioid overdose, opioid-related hospital admission/ED visit, in-hospital mortality, mechanical ventilation, and hospitalizations) between frequent (4+ visits), moderate (2-3 visits), and less frequent (1 visit) homeless individuals who had an ED visit in 2014, and (2) to identify predictors for increased ED use. I hypothesize that frequent ED (4+) users are more likely to have worse health services utilization outcomes than the moderate and less frequent ED users, and that moderate users have higher risk for these outcomes compared to the less frequent ED users. Frequent ED users are a subset of the homeless population who are chronically homeless and with dire unmanaged health conditions, such as diabetes, substance abuse, and mental health problems, and are more likely to return to the ED as a result. This study uses the same data source as the previous study and multivariable linear probability models with hospital fixed effects to model the association between ED visit count and health services utilization outcomes. Multinomial logistic regression and negative binomial models are used to identify predictors for higher ED use.

The last goal of this dissertation is to determine whether homeless pregnant women have worse childbirth delivery outcomes compared to non-homeless women. My objectives are: (1) to compare obstetrics (antepartum hemorrhage, placental abnormalities, premature rupture of the membranes, preterm labor, postpartum hemorrhage) and fetal (fetal distress, stillbirth, fetal growth restriction) outcomes, and hospital costs between homeless and non-homeless pregnant women, and (2) to assess whether the hospital where they received their care is at least partly responsible for this difference. Homeless pregnant women are more likely to have pre-existing conditions, and are less likely to receive prenatal care or have the resources to take care of their health during pregnancy, which can complicate their pregnancy and childbirth. Therefore, I hypothesize that homeless pregnant women are more likely to have worse maternal and fetal outcomes, and higher costs compared to non-homeless housed women, and that their outcomes are worse regardless of where they seek care. This analysis uses the 2014 State Inpatient Database for FL, MA and NY as the data source and the doubly-robust overlap propensity-score weighing method with regression adjustment with and without hospital fixed for the statistical analysis.

All three papers help us understand the adverse health outcomes, healthcare use, and expenditures associated with homelessness, which in turn can help to design policies that can target the unmet healthcare needs of this population.

1.2 Review of the Literature

Epidemiology of homelessness

According to the U.S. Department of Housing and Urban Development's 2019 Annual Homeless Assessment Report (AHAR) to Congress (U.S. Department of Housing and Urban Development, 2019), in January 2019 approximately 567,715 Americans experienced homelessness in any single night, which is equivalent to 17 per every 10,000 people in the US. Among this estimate, 63% stayed in emergency shelters or transitional housing programs while 37% were unsheltered. Point-in time estimates give an estimate of homeless status on a given night, however, homelessness is a dynamic status and the annual homeless counts are estimated to be approximately 2.5 - 3.5 million (Fazel et al., 2014; National Coalition for the Homeless, 2009).

One-third of those experiencing homelessness were people in families with children, 19% were children, 39% were women, 40% were African American (vs. 48% white and 7% multiracial) and 22% were Hispanic or Latino. 37,085 or 6.5% were veterans (U.S. Department of Housing and Urban Development, 2019); both male and women veterans have an increased risk for becoming homeless compared to nonveterans (Gamache, Rosenheck, & Tessler, 2001, 2003). The majority of the homeless are between the ages of 25 and 44 but the average age of the homeless is older now compared to a few decades ago (Culhane, Metraux, & Bainbridge, 2010; O'Connell et al., 2004). Individuals who experience a chronic pattern of homelessness represent 16.9% of all homeless individuals, an increase from 8% in the year prior. These are the people who cycle between the streets, shelters, hospitals, emergency departments, and other facilities, and are often homeless for years. Further, the degree of homelessness can vary from one city or region to another. In early 2019, nearly a quarter of the people experiencing homelessness were in New York City or Los Angeles. Whereas over 90% of homeless individuals New York City were sheltered, less than 15% of homeless individuals in Los Angeles were sheltered (U.S. Department of Housing and Urban Development, 2019).

Etiology of homelessness

There is no one single factor that leads to homelessness, nor is the path to homelessness linear or uniform, and it is currently understood to be caused by the interaction of individual, structural factors, and/or system failures. These individual factors include poverty, adverse childhood experiences including violence, having mental health and/or substance abuse problems, and association with the criminal justice system. Homeless individuals do not share many characteristics in common with each other besides being very vulnerable, poor, and without the necessary support system. It is interesting to note that the reasons for homelessness for the mentally ill are very similar to those without mental illnesses (Mojtabai, 2005). This suggests that structural solutions such as housing supports may be effective in reducing homelessness regardless of mental illness status.

Structural components are the broad economic and social factors that include the availability of affordable housing, employment opportunities, and a reduction or loss in public benefits (Fazel et al., 2014; Nunez & Cox, 1999; The Homeless Hub, 2017). Nunez and Cox offer evidence from a survey that a reduction or elimination of public assistance can lead to homelessness for approximately 15% of homeless families (Nunez & Cox, 1999). System failures include the lack of support for immigrants and refugees, people transitioning out of child welfare programs, and those who are being discharged from hospitals, correction facilities, and mental health and addiction facilities.

Among these, there is evidence that personal financial resources have the greatest weight. In one survey (Burt et al., 1999), the most important factor keeping a homeless person from exiting the streets was insufficient income (30%), followed by lack of a job (24%), lack of suitable housing (11%) and addiction to alcohol and drugs (9%). For homeless youths in both developed and developing countries, the most commonly cited reasons for homelessness were poverty, family conflict, and abuse, while delinquency was the least commonly cited reason (Embleton, Lee, Gunn, Ayuku, & Braitstein, 2016).

Health problems among persons who suffer from homelessness

Homeless persons have a higher prevalence of psychiatric disorders, substance abuse, disability, chronic illnesses, and mortality compared to non-homeless persons (Baggett et al., 2013). A 2001 community survey in Chicago indicated that 57% of the homeless had mental health, 62% had alcohol problems, 58% had drug problems, and more than three-quarters of the homeless had experienced an alcohol, drug, or mental health problem during their lifetime (Johnson & Fendrich, 2007). In a 2010 study conducted among the homeless covered under Medicaid in Boston, 68% had some form of mental illness, 19% had schizophrenia, 60% had any substance use disorders, and 40% had an alcohol use disorder (Bharel et al., 2013). Another study found that, during the past month, 38% of the homeless had alcohol problems, 26% had drug problems, and 39% had a mental health problem (Burt et al., 1999). Additionally, one-third were reported as having a current serious mental illness including schizophrenia, affective, personality, and cognitive disorders (Fischer, Shapiro, Breakey, Anthony, & Kramer, 1986). Opioid abuse among the homeless has not been studied extensively but is one of the most devastating public health crises today. In a cause of death study, as much as 81% of the drug overdose cases that led to death were a result of opioids (Baggett et al., 2013).

Several existing research suggest that homeless women have barriers accessing prenatal care (Bloom et al., 2004) and have fewer prenatal care visits (Richards et al., 2011). They also have a higher likelihood of giving birth to infants who are born preterm, have low birthweight, small for gestational age, need neonatal intensive care or longer lengths of stays (Little et al., 2005; Richards et al., 2011; Stein et al., 2000).

Infectious diseases, such as human immunodeficiency virus (HIV), Hepatitis B (HBV) and C (HCV), and tuberculosis prevalence are also much higher among the homeless population as a result of living in crowded shelters and sharing needles during injection drug use (Bamrah et al., 2013; Beijer, Wolf, & Fazel, 2012). In Boston in 2010, for instance, the prevalence of HIV was 6% (Bharel et al., 2013) compared to the general population prevalence of 0.36% (Centers for Disease Control and Prevention, 2018). Lack of adequate and appropriate housing is found to be a significant barrier for HIV patients to receive medical care, access and adhere to medications, reduce viral loads, and prevent transmission to others (Aidala et al., 2016).

A dearth of longitudinal studies has made it challenging to disentangle whether chronic conditions precede, cause, or occur as a result of homelessness. All three scenarios are probable (Institute of Medicine Committee on Health Care for Homeless People, 1988). For instance, people presenting to emergency departments could have a pre-existing substance abuse problem that was exacerbated by homelessness or the problem occurred as a downstream effect of being homeless. In one study, researchers who studied the health status of newly homeless individuals found these individuals carried a heavy disease burden and had frequent health services use in the year prior to becoming homeless (Schanzer, Dominguez, Shrout, & Caton, 2007). This supports the first case, but this sample was limited to individuals in shelters in New York City over an 18 month period. Further, acute conditions, such as physical assault and injuries, are also very common among this population (Hammig, Jozkowski, & Jones, 2014), and are likely to result from living on the streets.

Healthcare use among persons who suffer from homelessness

Prior to the passage of the Patient Protection and Affordable Care Act (ACA), homeless persons were more likely to be uninsured (Oates, Tadros, & Davis, 2009) and have greater barriers to accessing physical health services. As a result, they were less likely to have a regular source of care (Gelberg, Gallagher, Andersen, & Koegel, 1997; Kushel et al., 2001). In a national survey, 24.6% have reported being unable to receive needed medical services (Kushel et al., 2001). They have more frequent ED use and hospital inpatient stays than the general population (Kushel et al., 2002). While insurance appears to improve barriers to care and increase the number of ambulatory care visits, many insured homeless people are frequent ED utilizers (DiPietro, Kindermann, & Schenkel, 2012). One study found that even among the insured, homeless individuals had on average, 10 ambulatory visits, 4 ED visits and 1 hospitalization per year. One-fifth of the homeless population had 6 or more ED visits and 12% had 3 or more hospitalizations in a year (Bharel et al., 2013). In Baltimore, the twenty most frequent ED users who were insured accounted for over 2,000 emergency visits or 1.3% of all ED visits in 2005 (DiPietro et al., 2012).

Mortality among homeless individuals

Homeless individuals die younger and have higher mortality rates than the general population (Baggett et al., 2013). There were numerous publications from the Boston Health Care for the Homeless Program (BHCHP) studying the homeless population. One study assessing the causes of death among over 28,000 homeless individuals from 2003-2008 found that the main causes of death were drug overdose, cancer, and heart disease. What was striking was that the all-cause mortality rate among younger adults ages 25-44 was nine fold the rate for general Massachusetts (MA) population, and drug overdose, mainly from opioids, was the number one cause of death for this age group. Among 45-64 year-olds, cancer and heart diseases were the leading causes of death, and their all-cause mortality rates were 4.5 fold higher than the MA population. The study also found mortality rates to be higher among whites compared to non-whites (Baggett et al., 2013). An older study (1988-1993) from the same program found that HIV was the most common cause of death (Hwang et al., 1997). While the overall all-cause mortality rates have not changed over the decades, the cause of death for homeless individuals has shifted.

An older study conducted in Philadelphia, PA found that the age-adjusted mortality rate among the homeless was 3.5 times the mortality rate of the general population (Hibbs et al., 1994). Their sample was 10,715 homeless individuals during 1986 and 1988 and a total of 96 deaths during the study period. Fifty-three percent of the deaths occurred in the summer months, and injury, heart disease, and ill-defined causes were the leading causes of death. Further, while the mortality rate for each of the race and sex subgroups were higher among the homeless compared to the general Philadelphia population, the difference was the largest among white men and smallest among nonwhite men. They concluded that studying subgroups of homeless individuals warrants more attention.

Healthcare costs for homeless individuals

Resulting from their high disease burden and frequent use of emergency and inpatient services, homeless patients have higher healthcare expenditures than the general population. While the magnitude of the costs related to homeless healthcare utilization varies across studies and regions, there is consensus that homeless people have at least a several thousand dollars greater costs compared to the general population. In BHCHP in 2010, each homeless patient on Medicaid had average expenditures that totaled $2,036 per month compared to $568 per month for each MassHealth member. The study also found that 48% of total health expenditures were incurred by 10% of the population and more than half of healthcare expenditures were from hospitalizations and ED visits (Bharel et al., 2013). In Toronto, homeless people had $2,559 greater hospital admission costs compared to the housed population over a 5-year period (Hwang, Weaver, Aubry, & Hoch, 2011). The goal of the ACA was to provide affordable coverage and access to necessary care while reducing costs in the long term. Even with coverage, targeted interventions are necessary to see a sizable impact on healthcare costs (Hwang & Henderson, 2010).

Interventions and efforts to end homelessness

Results from interventions to improve the health, housing status, and reducing emergency and inpatient utilization costs of the homeless have been promising overall. The long-term implementation, sustainability, and scalability of these interventions, however, have yet to be studied. In particular, the “Housing First” (HF) model has been regarded as an effective approach to get people stably housed. First pioneered by the Pathways to Housing in New York City in the early 1990s, the model is based on the belief that housing is a human right and values consumer choice. The program places homeless individuals immediately into permanent housing without contingencies for psychiatric treatment or sobriety. It has been more effective than other programs that require stringent prerequisites for housing (Tsemberis, Gulcur, & Nakae, 2004). A large proportion of housed tenants have been found to remain stably housed in the long term compared to usual care (Tsemberis & Eisenberg, 2000).

The HF program has also been recognized internationally. For example, in 2008, the Canadian government allocated $119 million to fund the At-Home Chez-Soi Demonstration Project to target the homeless with severe mental illness. This consisted of a pragmatic randomized control trial and evaluation of a Housing First program in Vancouver, Winnipeg, Toronto, Montreal, and Moncton. The trial found that HF has been effective in helping people get stably housed, reducing in the number of days with alcohol problems (Kirst, Zerger, Misir, Hwang, & Stergiopoulos, 2015), and improving their quality of life compared to usual care treatment (Aubry, Nelson, & Tsemberis, 2015).

HF has also been associated with lowering emergency visits, hospital admissions, and costs. In New York City, HF led to a Medicaid savings of $9,526 per person over a two-year period (Lim et al., 2018). A randomized control trial in Chicago found that the HF intervention group had $6,307 per person lower annual costs compared to usual care. Those who were chronically homeless experienced an even greater cost savings ($9,809 per person) (Basu, Kee, Buchanan, & Sadowski, 2012). Furthermore, in Denver, the program reduced public costs associated with caring for the homeless from $43,239 to $11,694 per person annually by providing permanent homes (Perlman & Parvensky, 2006), and similarly, in Portland from $42,075 to $17,199 per person (Price, 2009).

Gaps in Literature

There are several important questions about the homeless that are relevant today that have not been answered in a broad and representative sample. In 2011, The National Health Care for the Homeless Council summarized interviews from homelessness experts and conducted a literature scan to determine research priorities on homelessness-related topics. One of their findings was that past research overemphasized on substance abuse and mental illness, while very few studies have assessed issues in a representative sample or in the pregnant homeless population (National Health Care for the Homeless Council and Health Care for the Homeless Clinicians' Network Research Coordinating Committee, 2005).

For instance, only a few recent studies have comprehensively studied homelessness in relation to healthcare utilization, outcomes, and expenditures at the regional or national level. Many of the large-scale representative studies were conducted several decades ago (Burt et al., 1999; Kushel et al., 2001). This is due in part to the limited availability of federal funding on this topic today (National Health Care for the Homeless Council and Health Care for the Homeless Clinicians' Network Research Coordinating Committee, 2005) compared to the 1980s, 1990s, and early 2000s (Baggett et al., 2011; Burt et al., 1999; Hibbs et al., 1994; Hwang et al., 1997; Institute of Medicine Committee on Health Care for Homeless People, 1988; Kushel et al., 2001).

Burt and colleagues conducted a nationally representative study using data from the 1996 National Survey of Homeless Assistance Providers and Clients, however, the findings are from data collected from October 1995 to November 1996 (Burt et al., 1999). Current homeless individuals are older than those from the 1990s (Culhane et al., 2010; O'Connell et al., 2004), therefore, it is critical to study the health consequences of homelessness in the context of this aging cohort. Other nationally representative studies have limitations such as generalizability limited to the US veteran population (Hastings et al., 2013; Tsai, Link, Rosenheck, & Pietrzak, 2016), diabetes patients at safety-net health centers (Berkowitz, Kalkhoran, Edwards, Essien, & Baggett, 2018), among homeless and runaway adolescents (Klein et al., 2000; Shelton, Taylor, Bonner, & van den Bree, 2009), and to emergency department encounters only (Ku et al., 2010; Tadros et al., 2016).

Only two recently published studies by the same authors used a large population-based cohort. Both studies analyzed the State Inpatient Database from Massachusetts, Florida, and New York to compare the following outcomes: risk-standardized hospitalization rates, in-hospital mortality rates, mean lengths of stay, and mean costs per day between homeless and non-homeless patients; and disparities in the intensity of care (Wadhera, Choi, Shen, Yeh, & Joynt Maddox, 2019) and mortality between homeless and non-homeless patients who were admitted to the hospital for cardiovascular conditions (Wadhera, Khatana, et al., 2019). These studies are limited to hospitalizations (State Inpatient Database) and do not account for health services outcomes that occur in treat-and-release ED visits nor have sought to understand other specialized outcomes, such as maternal and fetal outcomes, of hospitalized patients.

Other recent studies that extensively studied healthcare utilization and outcomes among homeless patients have been restricted to a single hospital or a major city such as Boston, Philadelphia, or Toronto, and with a limited sample size (Baggett et al., 2013; Bharel et al., 2013; Hibbs et al., 1994; Hwang et al., 2013). Others have been conducted in a subpopulation of homeless people who have particular conditions such as severe mental illnesses, HIV (Lim et al., 2018; Vijayaraghavan et al., 2013), etc. or those who have health insurance (Bharel et al., 2013). This leads to limited generalizability to the rest of the homeless population.

While there is an abundance of substance abuse and mental illness research in this population, there is a dearth of studies examining pregnancy and childbirth delivery outcomes of homeless women. Past pregnancy studies have also been limited with smaller samples, such as studies conducted in a single hospital (Little et al., 2005; Paterson & Roderick, 1990), city (Los Angeles) (Stein et al., 2000), or state (Massachusetts) (Clark et al., 2019). With homeless women and families becoming the fastest growing segment of the homeless population (Welch-Lazoritz, Whitbeck, & Armenta, 2015) and with an increase in homeless pregnant women in metropolitan cities (Shaban, Campos, Rutanashoodech, Villarreal, & Carroll, 2017), there is a need for large and current studies examining outcomes for this population.

Further, many recent studies that compare the homeless population with the housed population either do not have a comparable comparison group or do not implement methods to control for selection bias. For instance, some studies compare the homeless population to the general population (Oates et al., 2009; Smith et al., 2017; Tadros et al., 2016), which may not be an appropriate comparison since homeless individuals have different health and demographic profiles than the general population. Other studies matched the homeless and the control groups on several factors including age and sex (Saab, Nisenbaum, Dhalla, & Hwang, 2016; Smith et al., 2017). Koegel and Burnam conducted a study using multivariate matching methods to compare homeless adults in Los Angeles with a household sample however the study is from 1988 (Koegel & Burnam, 1988). Only a few studies, studies assessing housing impact, have used propensity scores to account for selection bias (Gilmer, 2016; Gilmer, Manning, & Ettner, 2009;

Horvitz-Lennon et al., 2009; Kertesz et al., 2009; Larimer et al., 2009). Thus, in addition to the need for longitudinal studies, new research that uses a current, more generalizable sample, with a comparable control group is needed.

Significance

A study investigating the effects of the homelessness on healthcare use and outcomes across multiple states in the US could potentially have a more meaningful impact on policies for the homeless and/or housing provision. The State Inpatient Database and the State Emergency Department Databases include all inpatient and emergency department discharges from community hospitals and hospital-affiliated emergency departments in that state, regardless of the payer and insured status of the patient. In addition to allowing for a comprehensive picture of the homeless population across different geographic regions, the large sample size makes subgroup analyses feasible. This could lead to policies that are targeted for a particular subgroup that could benefit the most from such reform and eventually lead to healthcare cost savings in the long run.

Chapter 1.3: Conceptual Framework

Figure 1.1. Conceptual Framework for Homelessness and Healthcare Use

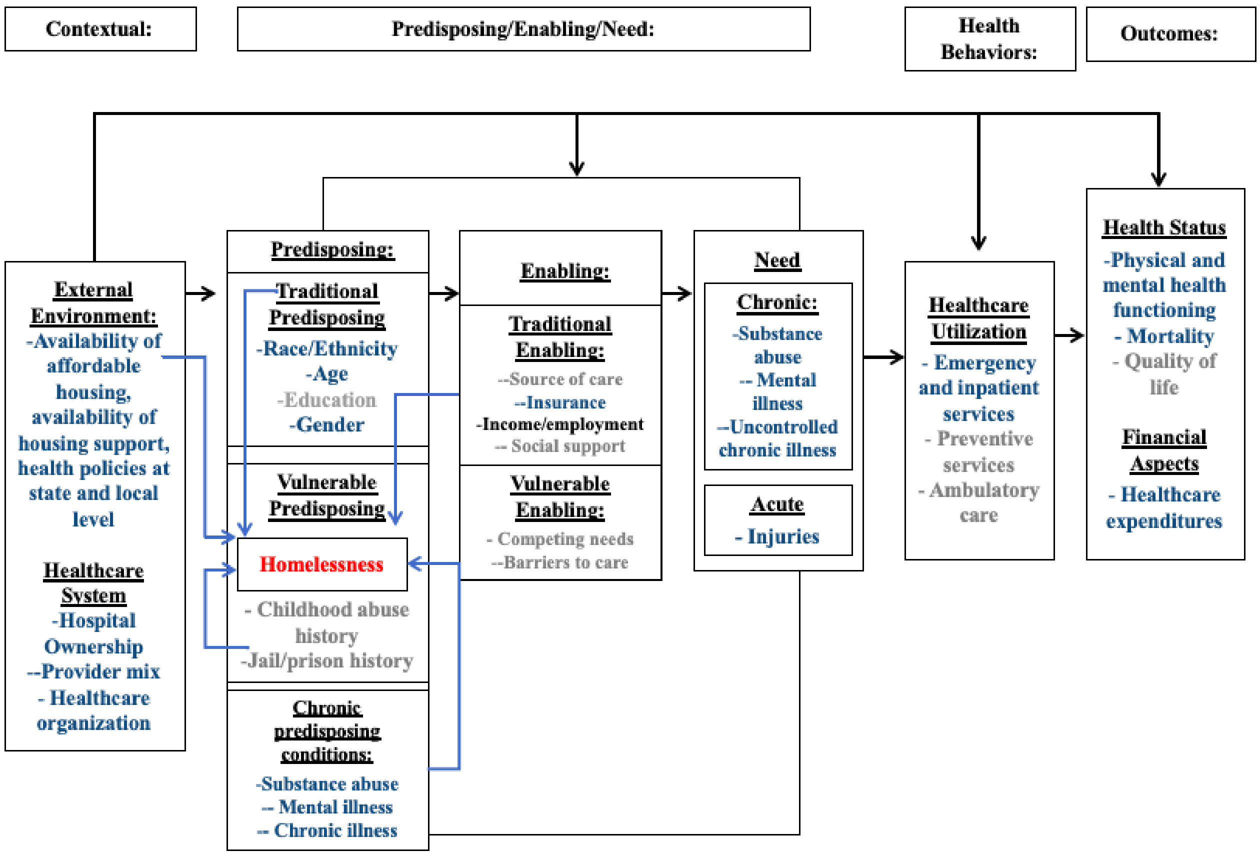
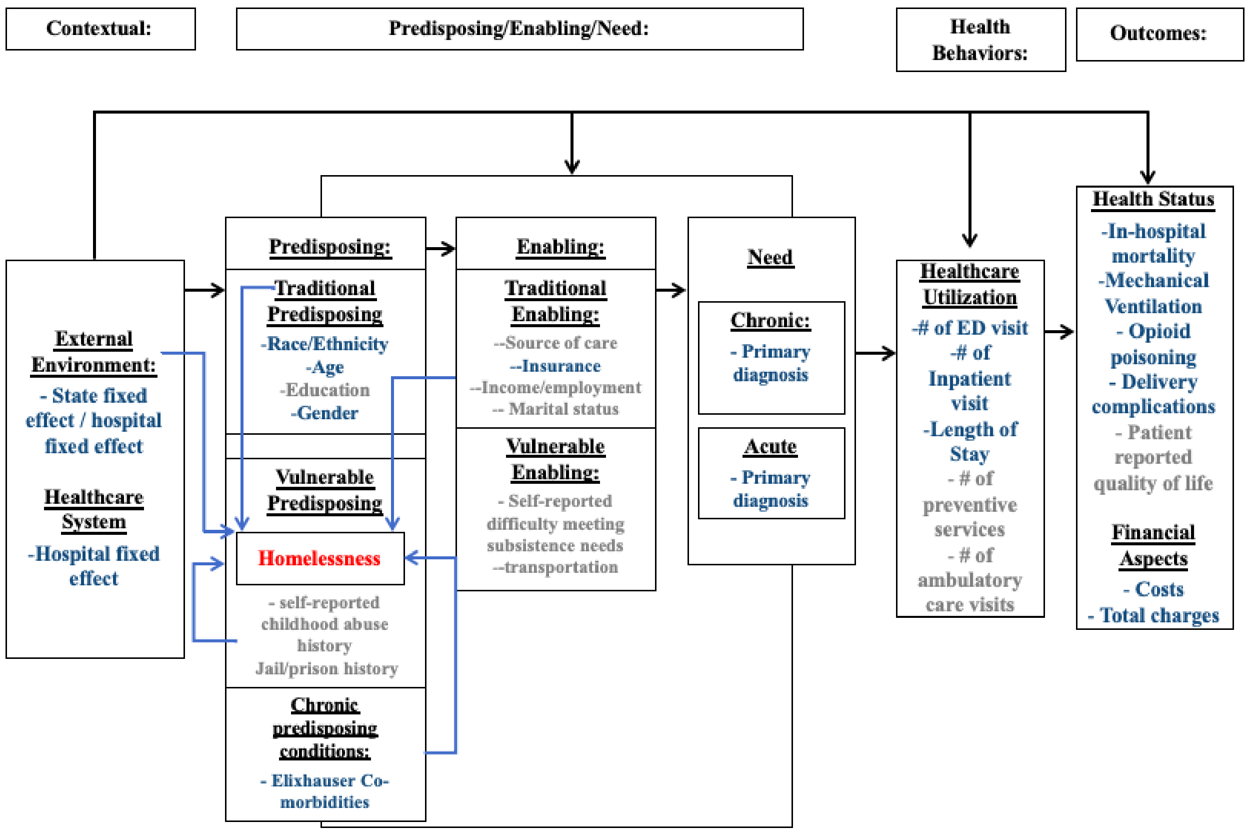


Figure 1.2. Measurement Model for Homelessness and Healthcare Use



*Note – Homelessness is bolded in **red**, concepts and measures that cannot be measured from the data are in **grey**, concepts proxied by measures that are available in the data are in **navy blue**, and factors that are upstream factors of homelessness are indicated by **blue** arrows are.

The conceptual framework for this dissertation is based on the Gelberg-Andersen Behavioral Model for Vulnerable Population as illustrated in Figure 1.1 (Gelberg, Andersen, & Leake, 2000). This framework is a version of the original Andersen Behavioral Model (Andersen, 1968), which explains the relationship between predisposing, enabling, and need factors that lead to healthcare utilization for a given population. Predisposing factors include age, gender and race/ethnicity that precede the perception of illness; enabling resources are those that facilitate or impede people from utilizing health services and need factors are physical and mental illnesses that lead to healthcare use. The framework attempts to distinguish measures of access, including potential access (i.e. enabling resources) from realized access (i.e. use of healthcare services). The Gelberg-Andersen Behavioral Model for Vulnerable Populations includes both traditional and vulnerable domains that apply to vulnerable populations, such as the homeless, racial/ethnic and gender minorities, children and adolescents, the elderly, the chronically and mentally ill, and undocumented immigrants among others. The framework for this dissertation has been further modified to include components that are associated and lead to homelessness. Since some of the factors that are related to homelessness and healthcare use overlap, the factors that are also associated with homelessness are indicated by the blue arrows. Since not all concepts can be proxied with the measures available in the databases, Figure 1.2 depicts the possible proxies and measures for the proxies in navy blue that are available in the data. Homeless status at the time of the encounter is also measured and is indicated in red.

Contextual

Precipitating factors that are both indirectly and directly associated with homelessness and healthcare use are multi-factorial and are classified into contextual factors, individual-level pre-disposing and individual-level enabling factors. Contextual factors include economic factors such as the availability of affordable housing and geographic location. Homeless individuals are more likely to be concentrated in cities as opposed to the suburbs or rural areas (Burt et al., 1999). The sudden rise in homelessness in the 1980s has been studied to be at least partly explained by the shortage of affordable housing. When there is income inequality, there is a greater demand for affordable housing among the poor, which in return drives up the cost of housing (Quigley, Raphael, Smolensky, Mansur, & Rosenthal, 2001).

Housing policies differ at the state and even at the local government level, which can influence the number of individuals who become and continue to remain homeless. While government subsidies for rental assistance are funded by the U.S. Department of Housing and Urban Development, eligibility for housing vouchers is determined by local public housing agencies. Individuals in areas with a higher demand for housing may experience longer waiting times than others. Other differences across different geographic areas include rent control regulations, tenant rights, and programs and resources dedicated to ending homelessness. State fixed effects, hospital fixed effects and rural/urban indicators can serve as proxies for time-invariant difference in state housing policies, availability of housing, etc. across states and regions. Hospitals, which are nested within states are proxies for local differences in housing policies and availability.

Similar to housing regulations, individual states have different policies for providing medical care access for the poor, which can impact their health services use. Prior to the Affordable Care Act, traditional Medicaid provided insurance coverage to low-income children, pregnant women, elderly and disabled individuals, and some parents, which left many low-income adults uninsured. Medicaid eligibility criteria differed across states. Under the Affordable Care Act, individual states were faced with the decision to adopt the Medicaid expansion, which extended Medicaid coverage to adults up to 138% of the federal poverty level (FPL). As of March 2020, 37 states have adopted this expansion (Kaiser Family Foundation, 2020). By January 2014, New York (Norris, 2017), Massachusetts (Kaiser Family Foundation, 2014) and Maryland (Norris, 2018), among other states had opted for the expansion, whereas

Florida is one of 17 states currently that have not opted for expansion. Individuals earning 100 – 400% of FPL are eligible for a marketplace subsidy, however, non-disabled adults living in the "non-expansion" state with incomes up to 100% of FPL are not eligible for Medicaid nor are they eligible to receive marketplace subsidies. This is often referred to as the "coverage gap." In Florida in 2016, there were approximately 384,000 uninsured adults who fell into this coverage gap (Garfield, Damico, & Orgera, 2018). Again, these unmeasured time-invariant state-level variances can be accounted for using state fixed effects and region/urban indicator, or hospital fixed effects for local differences.

Healthcare system-level factors such as hospital-specific policies, availability of resources and organization of services also fall under contextual factors. These are not directly linked to homelessness but are upstream factors that influence healthcare use. For instance, high hospital volume is associated with better outcomes, although the methodological rigor varies across studies (Halm, Lee, & Chassin, 2002). Hospital ID's used as hospital fixed effects will account for time-invariant differences in characteristics across hospitals.

Individual Pre-disposing

Individual pre-disposing factors are divided into both traditional and vulnerable domains. Traditional pre-disposing factors include social, demographic characteristics. Homelessness falls under the vulnerable pre-disposing domain, along with childhood abuse history, jail/prison history, chronic pre-existing health conditions, such as substance abuse and mental illnesses. As indicated by the blue arrows from traditional predisposing, prison or child abuse history and chronic pre-disposing factors to homelessness, some predisposing factors are also upstream factors that are associated with homelessness (Institute of Medicine Committee on Health Care for Homeless People, 1988). A study conducted from the 100000 Homes Campaign found that unsheltered status was positively associated with being a veteran, having less than high school education ("traditional predisposing"), accessing informal income, and having a history of foster care, chronic homelessness, incarceration or substance abuse ("predisposing") (Montgomery, Szymkowiak, Marcus, Howard, & Culhane, 2016).

As discussed previously in the literature review, there is no single factor that directly leads to homelessness, but rather a combination of factors. For instance, substance abuse ("predisposing") may be linked indirectly to homelessness through a mediating factor, lack of social support from family and friends ("enabling") or unemployment (Vangeest & Johnson, 2002). Another obvious pathway is when a lack of affordable housing ("external environment") and loss of employment and/or poverty ("enabling") (Quigley et al., 2001) lead to the loss of a home.

Homelessness status at the time of discharge, race/ethnicity, gender, and age are captured in the SID/SEDD data. While historical measures, such as self-reported jail/prison history, cannot be captured in these cross-sectional databases, Elixhauser co-morbidities can proxy for chronic predisposing conditions.

Individual enabling

The traditional domains of individual enabling resources include the source of care, income/employment, health insurance, and social support. Homeless individuals are also more likely to be uninsured ("enabling"), have dire health conditions ("predisposing") and rely on the acute hospital-based care as their regular source of care ("enabling") (Gallagher, Andersen, Koegel, & Gelberg, 1997; Karaca, Wong, & Mutter, 2013; Kushel et al., 2001). The vulnerable domains include competing needs and barriers to care. Homeless individuals have more immediate needs, such as housing and food, that compete with healthcare (Gelberg et al., 1997).

Furthermore, once someone becomes homeless, their healthcare services use is mediated by enabling factors and their health needs. Homeless individuals with a regular source of care are less likely to have unmet needs (Lewis, Andersen, & Gelberg, 2003). Having insurance and the insurance type may enable individuals to have regular check-ups and chronic disease monitoring with a primary care physician, as opposed to fragmented care across multiple healthcare systems and providers (Kushel et al., 2001). The role of insurance, however, has been mixed. Past studies have found that insured homeless individuals are more likely to use ED and inpatient services compared to insured non-homeless individuals (Bharel et al., 2013; Hwang et al., 2013; Tsai, Doran, & Rosenheck, 2013). In my studies, primary expected payer proxies for insurance.

The arrow originating from enabling to health needs indicate that regardless of whether a person is homeless, having a pre-existing condition ("pre-disposing") but no health insurance and/or having other barriers to accessing care ("enabling") can lead people to delay treatment and have exacerbated health conditions ("need") (Hadley, 2007; Institute of Medicine, 2004). Both predisposing and enabling factors are both independently associated with healthcare utilization and outcomes. For instance, women, in general, are more likely to utilize health services compared to men (Kaiser Family Foundation, 2015). Likewise, the elderly are more vulnerable and are likely to have higher healthcare costs and mortality rates than individuals in other age groups (Gregersen, 2014; Lassman, Hartman, Washington, Andrews, & Catlin, 2014).

Individual Need

Health needs are further broken down into chronic health, such as uncontrolled diabetes, alcohol and substance abuse, mental illness; and acute health needs, such as injuries from living on the streets. As discussed previously in the literature review, there are two pathways that lead homeless individuals to utilize emergent health services. They are chronic and acute conditions that emerge as a result of being homeless, and separately, “chronic pre-disposing conditions” that are exacerbated by becoming homeless. There is an arrow pointing from the “chronic predisposing factors” to homelessness to indicate the latter scenario. Since homeless individuals are less likely to have regular check-ups for their mental and chronic health maintenance, their condition tends to remain untreated (latter scenario) (Schanzer et al., 2007). Living on the streets also make homeless individuals more vulnerable to assaults and sicknesses resulting from harsh living conditions (former scenario) (Institute of Medicine Committee on Health Care for Homeless People, 1988). These “need” factors are proxied by the top 10 most prevalent primary diagnosis codes among the homeless population. Primary diagnosis is the primary reason that he/she came to the emergency department or for an inpatient hospital visit.

Individual Health Behavior and Outcomes

Health services utilization consists of emergent services, such as ED and inpatient hospital services, as well as ambulatory and preventive services. Homeless individuals are less likely to use ambulatory care services and more likely to be hospitalized (Fischer et al., 1986). Health service utilization then feeds into “Outcomes,” which are composed of mental and physical health status and financial outcomes. For instance, frequent ED use is directly related to higher healthcare expenditures (Bharel et al., 2013). Due to the nature of these data, ambulatory and preventive care visits are not captured. The number of ED visits, the number of hospitalizations, and length of stays are measured proxies for emergent health services use. Physical and mental health status are proxied by in-hospital mortality, mechanical ventilation event, delivery complications, and opioid poisoning. While it is not feasible to measure total economic costs, healthcare expenditures are approximated by total inpatient costs.

CHAPTER II: ASSOCIATION BETWEEN HOMELESSNESS AND OPIOID OVERDOSE AND OPIOID-RELATED HOSPITAL ADMISSIONS/EMERGENCY DEPARTMENT VISITS[1]

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.

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.

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[1] The study in this chapter was published in October 2019:

Yamamoto A, Needleman J, Gelberg L, Kominski G, Shoptaw S, Tsugawa Y. Association between homelessness and opioid overdose and opioid-related hospital admissions/emergency department visits. Soc Sci Med. 2019;242:112585.

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.

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 (National Institute on Drug Abuse, 2018), and its total economic burden is estimated to be over $500 billion annually (Council of Economic Advisors, 2017). 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 (Dyer, 2018). 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 (National Coalition for the Homeless, 2009), and over 550,000 people are homeless on any given night (Fazel et al., 2014; U.S. Department of Housing and Urban Development, 2017). Homeless individuals experience higher chronic and acute disease burdens (Bharel et al., 2013; Institute of Medicine Committee on Health Care for Homeless People, 1988); higher mortality rates (Baggett et al., 2013; Hibbs et al., 1994); and are more likely to utilize costly emergency department and hospital inpatient services compared to housed individuals (Bharel et al., 2013; Kushel et al., 2002; Kushel et al., 2001). 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 (Baggett et al., 2013; Doran et al., 2018). However, these studies are limited as they were conducted in a single city or hospital (in Boston or New York City) (Baggett et al., 2013; Doran et al., 2018), or among Veterans (Iheanacho, Stefanovics, & Rosenheck, 2018; Midboe et al., 2019) 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 (Dowell, Haegerich, & Chou, 2016), accurate prediction models for opioid overdose have not yet been developed. Furthermore, existing prediction models do not include homeless status as a key predictor (Becker, Sullivan, Tetrault, Desai, & Fiellin, 2008; Bohnert et al., 2011; Cepeda, Fife, Chow, Mastrogiovanni, & Henderson, 2012; Cochran et al., 2017; Dunn et al., 2010; Glanz et al., 2018; Gwira Baumblatt et al., 2014; Hall et al., 2008; Hylan et al., 2015; Ives et al., 2006; Lo-Ciganic et al., 2019; Oliva et al., 2017; Rice et al., 2012; Rose et al., 2018; Sullivan et al., 2010; Webster et al., 2011; Webster & Webster, 2005; A. G. White, Birnbaum, Schiller, Tang, & Katz, 2009; B. Zedler et al., 2015; B. K. Zedler, Saunders, Joyce, Vick, & Murrelle, 2018). 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 (Healthcare Cost and Utilization Project (HCUP), 2018). 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 (Healthcare Cost and Utilization Project (HCUP), 2008). 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 (Karaca et al., 2013; Manzano-Nunez et al., 2019; Rosendale, Guterman, Betjemann, Josephson, & Douglas, 2019; R. Sun, Karaca, & Wong, 2006; B. White, Ellis, Jones, Moran, & Simpson, 2018; B. M. White, Ellis, & Simpson, 2014).

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 (Larochelle, Zhang, Ross-Degnan, & Wharam, 2015). 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 (Weiss & Heslin, 2006).

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 (Healthcare Cost and Utilization Project (HCUP), 2017) (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 (Fizmaurice, Laird, & Ware, 2011). 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 (Hellevik, 2009)), 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 (Williams, 2012).

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 (Lin, Psaty, & Kronmal, 1998).

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 2.1).

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 2.2).

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 2.1 and Appendix Tables 2.1A and 2.1B). 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 2.2 and Appendix Tables 2.1A and 2.1B).

Secondary analyses

Overall, our findings for both opioid outcomes were not sensitive to restricting the analysis to NY and MA (Appendix Table 2.2), to male patients (Appendix Table 2.3), or to patients with ED visits only (Appendix Table 2.4). Homeless individuals, on average, had greater number of ED and inpatient visits per person compared to low-income housed individuals (Appendix Table 2.5). 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 (Appendix Table 2.6).

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 (Dowell et al., 2016), 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 (Lo-Ciganic et al., 2019). 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 (Didenko & Pankratz, 2007; National Coalition for the Homeless, 2017). 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 (Chatterjee, Yu, & Tishberg, 2018; Johnson, Freels, Parsons, & Vangeest, 1997; National Coalition for the Homeless, 2017). 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 (Upshur, Jenkins, Weinreb, Gelberg, & Orvek, 2018), 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 (Shah, Galai, Celentano, Vlahov, & Strathdee, 2006). 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 (Meges et al., 2014). Moreover, not all community health centers provide medication-assisted treatments, and among those that do, the majority of the clinics face provider shortages (Zur & Tolbert, 2018).

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 (Miller & Moriya, 2018). 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 (Rosenbloom et al., 2018). 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 (Anderson, Green, & Payne, 2009; Cintron & Morrison, 2006; Hirsh, Hollingshead, Ashburn-Nardo, & Kroenke, 2015).

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) (Baggett et al., 2013; Doran et al., 2018) or among Veterans (Iheanacho et al., 2018; Midboe et al., 2019). 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 (U.S. Department of Housing and Urban Development, 2017). 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 (Doran et al., 2018; Marshall et al., 2018). 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 (Baggett et al., 2013). 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 (Doran et al., 2018).

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.

Limitations

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 (Appendix Table 2.2). 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.

CONCLUSIONS

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.

Table 2.1. 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%)	<0.0001
Private insurance	3,803 (4.0%)	672,970 (23.6%)	
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%)		
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

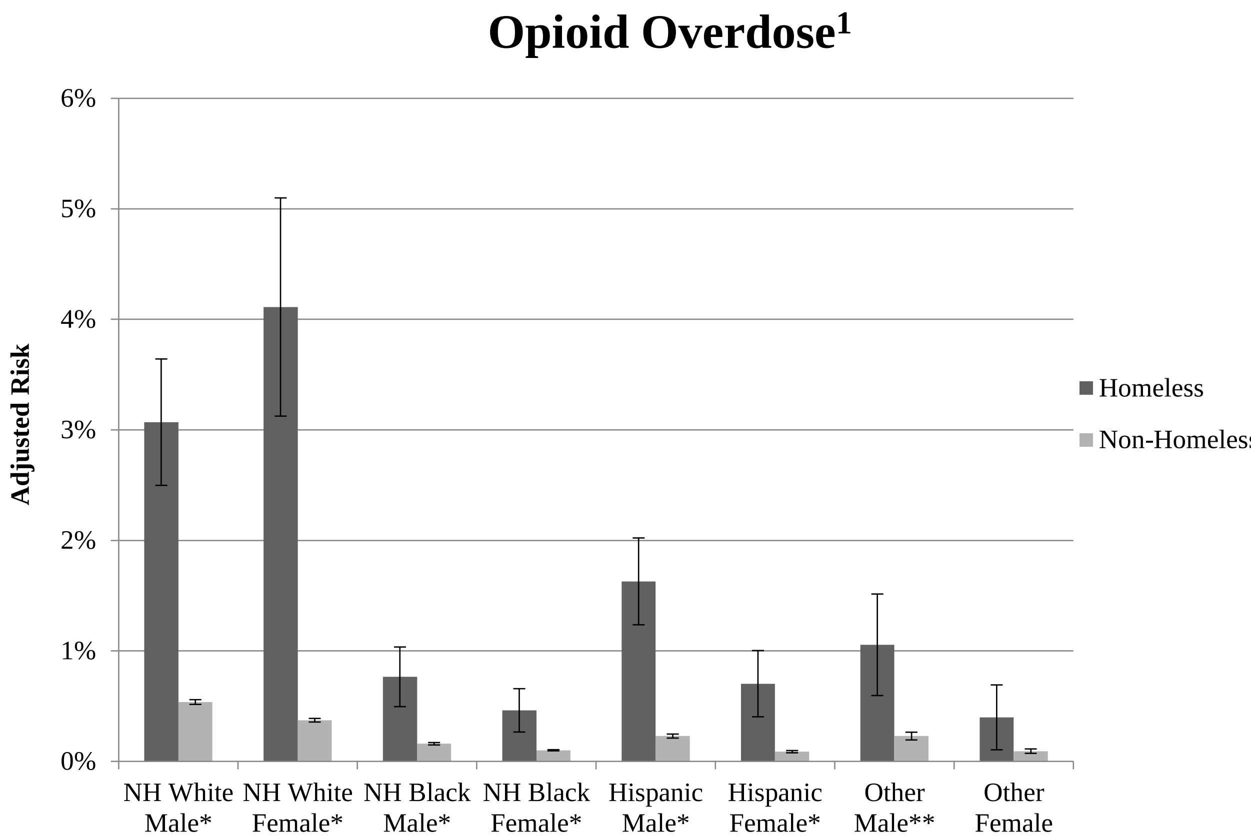
*Low-income housed individuals were defined as individuals who live in areas with the lowest quartile of the median household income.

Table 2.2. 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%)		

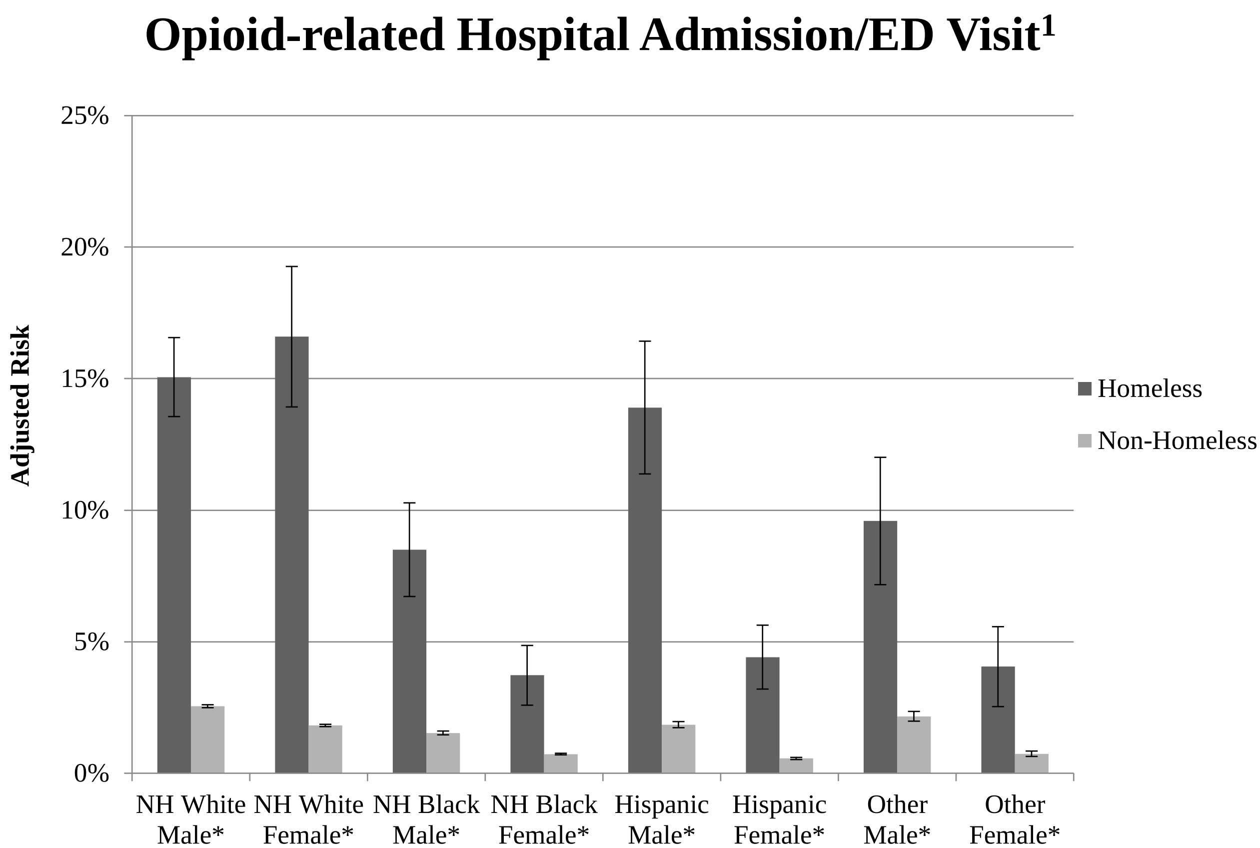
*Adjusted for patient characteristics and hospital-specific fixed effects. Low-income housed refers to individuals who live in areas with the lowest quartile of the median household income

Figure 2.1. 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 2.2. 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

Appendix

Table 2.1A. Comparison of unadjusted opioid outcomes for homeless compared to low-income housed individuals in emergent care, by gender and race/ethnicity

Outcome	Race/ethnicity	Unadjusted risk (95% CI)		Unadjusted risk difference (95% CI)		Wald *P* value
		Homeless	Non-Homeless	Homeless – Non-Homeless	*P* value	
Opioid Overdose	Non-Hispanic White Male	**4.2%** (3.9% to 4.5%)	**0.5%** (0.5% to 0.5%)	**3.7%** (3.4% to 4.0%)	<0.001	<0.001
	Non-Hispanic White Female	**4.4%** (4.0% to 4.8%)	**0.4%** (0.4% to 0.4%)	**4.1%** (3.7% to 4.5%)	<0.001	
	Non-Hispanic Black Male	**0.8%** (0.7% to 1.0%)	**0.2%** (0.1% to 0.2%)	**0.7%** (0.5% to 0.8%)	<0.001	
	Non-Hispanic Black Female	**0.5%** (0.4% to 0.6%)	**0.1%** (0.1% to 0.1%)	**0.4%** (0.3% to 0.5%)	<0.001	
	Hispanic Male	**1.8%** (1.5% to 2.0%)	**0.2%** (0.2% to 0.2%)	**1.5%** (1.3% to 1.8%)	<0.001	
	Hispanic Female	**0.6%** (0.5% to 0.8%)	**0.1%** (0.1% to 0.1%)	**0.5%** (0.4% to 0.7%)	<0.001	
	Other Male	**0.9%** (0.7% to 1.1%)	**0.2%** (0.2% to 0.3%)	**0.7%** (0.4% to 0.9%)	<0.001	
	Other Female	**0.3%** (0.2% to 0.4%)	**0.1%** (0.1% to 0.1%)	**0.2%** (0.1% to 0.3%)	0.003	
Opioid-related ED Visit/Hospital Admission	Non-Hispanic White Male	**19.5%** (19.0% to 20.1%)	**2.4%** (2.4% to 2.5%)	**17.1%** (16.6% to 17.7%)	<0.001	<0.001
	Non-Hispanic White Female	**18.2%** (17.5% to 19.0%)	**1.8%** (1.8% to 1.8%)	**16.4%** (15.7% to 17.2%)	<0.001	
	Non-Hispanic Black Male	**9.8%** (9.3% to 10.2%)	**1.5%** (1.4% to 1.5%)	**8.4%** (7.8% to 8.8%)	<0.001	
	Non-Hispanic Black Female	**4.0%** (3.7% to 4.3%)	**0.7%** (0.7% to 0.8%)	**3.3%** (2.9% to 3.6%)	<0.001	
	Hispanic Male	**15.0%** (14.4% to 15.7%)	**1.8%** (1.8% to 1.9%)	**13.3%** (12.6% to 13.9%)	<0.001	
	Hispanic Female	**4.2%** (3.8% to 4.5%)	**0.6%** (0.6% to 0.6%)	**3.6%** (3.2% to 4.0%)	<0.001	
	Other Male	**8.7%** (8.0% to 9.4%)	**2.2%** (2.1% to 2.3%)	**6.4%** (5.8% to 7.1%)	<0.001	
	Other Female	**3.0%** (2.6% to 3.4%)	**0.8%** (0.8% to 0.9%)	**2.2%** (1.8% to 2.6%)	<0.001	

Table 2.1B. Comparison of adjusted opioid outcomes for homeless compared to low-income housed individuals in emergent care, by gender and race/ethnicity

Outcome	Race/ethnicity	Adjusted risk (95% CI)		Adjusted risk difference (95% CI)		Wald *P* value
		Homeless	**Non-Homeless**	**Homeless – Non-Homeless**	***P* value**	
Opioid Overdose	Non-Hispanic White Male	**3.1%** (2.5% to 3.6%)	**0.5%** (0.5% to 0.6%)	**2.5%** (1.9% to 3.1%)	<0.001	<0.001
	Non-Hispanic White Female	**4.1%** (3.1% to 5.1%)	**0.4%** (0.4% to 0.4%)	**3.7%** (2.7% to 4.8%)	<0.001	
	Non-Hispanic Black Male	**0.8%** (0.5% to 1.0%)	**0.3%** (0.2% to 0.2%)	**0.6%** (0.3% to 0.9%)	<0.001	
	Non-Hispanic Black Female	**0.5%** (0.3% to 0.7%)	**0.1%** (0.1% to 0.1%)	**0.4%** (0.2% to 0.6%)	<0.001	
	Hispanic Male	**1.6%** (1.2% to 2.0%)	**0.2%** (0.2% to 0.3%)	**1.4%** (1.0% to 1.8%)	<0.001	
	Hispanic Female	**0.7%** (0.4% to 1.0%)	**0.1%** (0.1% to 0.1%)	**0.6%** (0.3% to 0.9%)	<0.001	
	Other Male	**1.1%** (0.6% to 1.5%)	**0.2%** (0.2% to 0.3%)	**0.8%** (0.3% to 1.3%)	0.001	
	Other Female	**0.4%** (0.1% to 0.7%)	**0.1%** (0.1% to 0.1%)	**0.3%** (-0.01% to 0.6%)	0.057	
Opioid-related ED Visit/Hospital Admission	Non-Hispanic White Male	**15.1%** (13.6% to 16.6%)	**2.6%** (2.5% to 2.6%)	**12.5%** (11.0% to 14.1%)	<0.001	<0.001
	Non-Hispanic White Female	**16.6%** (13.9% to 19.3%)	**1.8%** (1.8% to 1.9%)	**14.8%** (12.1% to 17.5%)	<0.001	
	Non-Hispanic Black Male	**8.5%** (6.7% to 10.3%)	**1.5%** (1.5% to 1.6%)	**7.0%** (5.1% to 8.8%)	<0.001	
	Non-Hispanic Black Female	**3.7%** (2.6% to 4.9%)	**0.7%** (0.7% to 0.8%)	**3.0%** (1.8% to 4.2%)	<0.001	
	Hispanic Male	**13.9%** (11.4% to 16.4%)	**1.9%** (1.7% to 2.0%)	**12.1%** (9.4% to 14.7%)	<0.001	
	Hispanic Female	**4.4%** (3.2% to 5.6%)	**0.6%** (0.5% to 0.6%)	**3.9%** (2.6% to 5.1%)	<0.001	
	Other Male	**9.6%** (7.2% to 12.0%)	**2.2%** (2.0% to 2.4%)	**7.4%** (4.8% to 10.0%)	<0.001	
	Other Female	**4.1%** (2.5% to 5.6%)	**0.7%** (0.6% to 0.8%)	**3.3%** (1.8% to 4.9%)	<0.001	

Table 2.2. Unadjusted and adjusted opioid-related adverse health outcomes between homeless compared to low-income housed individuals in MA and NY (sensitivity analysis)

		No. of individuals	Unadjusted risk (95% CI)	Adjusted risk (95% CI)	Adjusted risk difference (95% CI)	*P* value
Opioid Overdose	Homeless	1,516	**2.1%** (1.5% to 2.8%)	**1.9%** (1.3% to 2.5%)	**1.7%** (1.0% to 2.3%)	<0.001
	Low-income Housed	2,752	**0.2%** (0.2% to 0.3%)	**0.3%** (0.2% to 0.3%)		
Opioid-related ED Visit/ Hospital Admission	Homeless	8,831	**12.6%** (10.1% to 15.2%)	**11.3%** (9.1% to 13.6%)	**9.5%** (7.1% to 11.9%)	<0.001
	Low-income Housed	19,287	**1.7%** (1.6% to 1.9%)	**1.8%** (1.7% to 2.0%)		

Table 2.3. Unadjusted and adjusted opioid-related adverse health outcomes between homeless compared to low-income housed male patients (sensitivity analysis)

		No. of individuals	Unadjusted risk (95% CI)	Adjusted risk (95% CI)	Adjusted risk difference (95% CI)	*P* value
Opioid Overdose	Homeless	1,208	**2.2%** (1.7% to 2.6%)	**1.9%** (1.5% to 2.4%)	**1.6%** (1.2% to 2.1%)	<0.001
	Low-income Housed	3,923	**0.3%** (0.3% to 0.3%)	**0.3%** (0.3% to 0.4%)		
Opioid-related ED Visit/ Hospital Admission	Homeless	7,651	**14.1%** (12.5% to 15.6%)	**12.6%** (11.1% to 14.0%)	**10.5%** (9.0% to 12.0%)	<0.001
	Low-income Housed	24,752	**2.0%** (1.9% to 2.1%)	**2.1%** (2.0% to 2.1%)		

Table 2.4. Unadjusted and adjusted opioid-related adverse health outcomes between homeless compared to low-income housed patients with ED visits only (sensitivity analysis)

		No. of individuals	Unadjusted risk (95% CI)	Adjusted risk (95% CI)	Adjusted risk difference (95% CI)	*P* value
Opioid Overdose	Homeless	1,826	**2.4%** (1.9% to 3.0%)	**1.8%** (1.4% to 2.3%)	**1.6%** (1.1% to 2.0%)	<0.001
	Low-income Housed	7,143	**0.6%** (0.5% to 0.7%)	**0.3%** (0.3% to 0.3%)		
Opioid-related ED Visit/ Hospital Admission	Homeless	10,586	**13.4%** (11.5% to 15.3%)	**10.6%** (8.9% to 12.3%)	**9.1%** (7.3% to 10.8%)	<0.001
	Low-income Housed	41,088	**3.0%** (2.5% to 3.6%)	**1.5%** (1.5% to 1.6%)		

Table 2.5. Mean and median # of ED and inpatient visits per person by homeless status

	Homeless	**Low-income housed**
Total ED visits	467,161	5,758,621
Mean ED visits/person (SD)	4.9 (6.6)	2.0 (2.3)
Median ED visits/person	3.0	1.0
Total inpatient visits	176,088	1,409,084
Mean inpatient visits/person (SD)	1.8 (2.5)	0.5 (1.1)
Median inpatient visits/person	1.0	0.0

Table 2.6. Sensitivity of regression results to unmeasured confounding

Opioid-related admissions/ ED (OR = 5.23)							
		P0					
Γ	P1	0	0.1	0.2	0.3	0.4	0.5
2.88 liver disease	0	5.23					
	0.1	4.40	5.23	6.06			
	0.2	3.80	4.52	5.23	5.94	6.66	
	0.3	3.34	3.97	4.60	5.23	5.86	6.49
	0.4	2.99	3.55	4.11	4.67	5.23	5.79
	0.5	2.70	3.20	3.71	4.22	4.72	5.23
3.21 psychological disorders	0	5.23					
	0.1	4.28	5.23	6.18			
	0.2	3.63	4.43	5.23	6.03	6.83	
	0.3	3.14	3.84	4.53	5.23	5.93	6.62
	0.4	2.78	3.39	4.00	4.62	5.23	5.84
	0.5	2.48	3.03	3.58	4.13	4.68	5.23

Opioid overdose (OR = 5.03)							
		P0					
Γ	P1	0	0.1	0.2	0.3	0.4	0.5
2.41 depression	0	5.03					
	0.1	4.41	5.03	5.65			
	0.2	3.92	4.48	5.03	5.58	6.14	
	0.3	3.53	4.03	4.53	5.03	5.53	6.03
	0.4	3.22	3.67	4.12	4.58	5.03	5.48
	0.5	2.95	3.37	3.78	4.20	4.61	5.03
2.96 psychological disorders	0	5.03					
	0.1	4.21	5.03	5.85			
	0.2	3.61	4.32	5.03	5.74	6.45	
	0.3	3.17	3.79	4.41	5.03	5.65	6.27
	0.4	2.82	3.37	3.92	4.48	5.03	5.58
	0.5	2.54	3.04	3.54	4.03	4.53	5.03

We assessed the sensitivity of regression results to unmeasured confounders (Lin et al., 1998). This test allowed us to determine whether an unmeasured confounder could potentially explain the difference in opioid outcomes between homeless and low-income housed individuals. In Table 2.7, P_0 and P_1 are the proportion of patients with the unmeasured confounder among low-income housed patients and homeless patients, respectively. Γ is the strength of the association between the unmeasured confounder and the opioid outcomes. First, we modeled both opioid-related admissions/ED visits and opioid-overdose using logistic regression models to obtain ORs. Next we identified two co-morbidities from the Elixhauser co-morbidity conditions associated with the highest risks for these outcomes. We used these ORs as values for Γ. The OR's presented in the table are calculated based on varying degrees of unmeasured confounding.

When there is no residual confounding or the confounder affects homeless and low-income housed individuals equally, we obtain an adjusted OR of 5.23 for opioid-related admission/ED visits and OR = 5.03 for opioid overdose. For the former outcome in the presence of an unmeasured confounder as strong as psychological disorders (OR = 3.21), even a 50 percentage point difference in the prevalence of this unmeasured confounder between homeless and low-income housed patients cannot explain the difference in opioid-related admission/ED risk because we still obtain an adjusted OR of 2.48. For opioid overdose, we still obtain an adjusted OR of 2.54 in the presence of a confounder of similar magnitude.

Table 2.7. Baseline characteristics homeless vs. low-income housed individuals in emergent care (lowest income quartile) by state

State	FL			MD			MA			NY		
	Homeless (N=18572)	Low-income Housed (N=1676248)	*P* value	Homeless (N=1109)	Low-income Housed (N=107438)	*P* value	Homeless (N=13551)	Low-income Housed (N=149529)	*P* value	Homeless (N=62768)	Low-income Housed (N=921683)	*P* value
Age in years at admi ssion			<0.0001			<0.0001			0.9944			<0.0001
Mean (SD)	43.9 (13.86)	49.3 (20.59)		42.3 (14.13)	43.5 (18.06)		42.3 (14.39)	43.7 (18.78)		50.1 (19.37)	44.5 (18.76)	
Sex			<0.0001			<0.0001			<0.0001			<0.0001
Female vs. Male	5246 (28.2%)	949679 (56.7%)		308 (27.8%)	59753 (55.6%)		4442 (32.8%)	82569 (55.2%)		32709 (52.1%)	515820 (56%)	
Primary expected payer			<0.0001			<0.0001			<0.0001			<0.0001
Medicaid	3021 (16.3%)	300596 (17.9%)		510 (46%)	43409 (40.4%)		7060 (52.1%)	57537 (38.5%)		40427 (64.4%)	347025 (37.7%)	
Medicare	2557 (13.8%)	515043 (30.7%)		138 (12.4%)	20400 (19%)		2871 (21.2%)	34376 (23%)		15593 (24.8%)	172741 (18.7%)	
Private insurance	901 (4.9%)	406711 (24.3%)		60 (5.4%)	24441 (22.7%)		1534 (11.3%)	36286 (24.3%)		1308 (2.1%)	205532 (22.3%)	
Self-pay	9845 (53%)	349280 (20.8%)		311 (28%)	15742 (14.7%)		707 (5.2%)	7886 (5.3%)		4987 (7.9%)	165523 (18%)	
No charge/Other	2248 (12.1%)	104618 (6.2%)		90 (8.1%)	3446 (3.2%)		1379 (10.2%)	13444 (9%)		453 (0.7%)	30862 (3.3%)	
Race/ethnicity			<0.0001			<0.0001			<0.0001			<0.0001
Non-Hispanic White	12113 (65.2 %)	872152 (52%)		419 (37.8%)	26800 (24.9%)		8791 (64.9%)	62271 (41.6%)		8698 (13.9%)	199312 (21.6%)	
Non-Hispanic Black	3693 (19.9%)	464720 (27.7%)		506 (45.6%)	76521 (71.2%)		2448 (18.1%)	26550 (17.8%)		22343 (35.6%)	338399 (36.7%)	
Hispanic	2328 (12.5%)	302759 (18.1%)		119 (10.7%)	1834 (1.7%)		1988 (14.7%)	53645 (35.9%)		18760 (29.9%)	236998 (25.7%)	
Other	438 (2.4%)	36617 (2.2%)		65 (5.9%)	2283 (2.1%)		324 (2.4%)	7063 (4.7%)		12967 (20.7%)	146974 (15.9%)	
Total # of Elixhauser conditions			<0.0001			0.0016			<0.0001			<0.0001
Mean (SD)	0.6 (1.3)	0.6 (1.4)		0.8 (1.2)	0.7 (1.3)		0.9 (1.2)	0.7 (1.21		1.5 (1.6)	0.7 (1.3)	
Elixhauser co-morbidities												
Alcohol abuse	1335 (7.2%)	21195 (1.3%)	<0.0001	136 (12.3%)	2822 (2.6%)	<0.0001	1504 (11.1%)	2888 (1.9%)	<0.0001	4219 (6.7%)	17771 (1.9%)	<0.0001

Drug abuse	1317 (7.1%)	17953 (1.1%)	<0.0001	111 (10%)	5027 (4.7%)	<0.0001	1924 (14.2%)	3272 (2.2%)	<0.0001	5337 (8.5%)	20085 (2.2%)	<0.0001
Psychoses	638 (3.4%)	17449 (1%)	<0.0001	73 (6.6%)	2280 (2.1%)	<0.0001	1081 (8%)	2519 (1.7%)	<0.0001	2964 (4.7%)	15232 (1.7%)	<0.0001
Depression	478 (2.6%)	38909 (2.3%)	0.0231	49 (4.4%)	2790 (2.6%)	0.0002	1056 (7.8%)	6240 (4.2%)	<0.0001	2625 (4.2%)	25875 (2.8%)	<0.0001
Hypertension	1689 (9.1%)	235596 (14.1%)	<0.0001	166 (15%)	23783 (22.1%)	<0.0001	1876 (13.8%)	26563 (17.8%)	<0.0001	21420 (34.1%)	190754 (20.7%)	<0.0001
Congestive heart failure	107 (0.6%)	27082 (1.6%)	<0.0001	-	1598 (1.5%)	0.0356	111 (0.8%)	2270 (1.5%)	<0.0001	2266 (3.6%)	15648 (1.7%)	<0.0001
Valvular disease	57 (0.3%)	15543 (0.9%)	<0.0001	-	720 (0.7%)	0.0459	39 (0.3%)	701 (0.5%)	0.0027	693 (1.1%)	5712 (0.6%)	<0.0001
Pulmonary circulation disease	43 (0.2%)	7380 (0.4%)	<0.0001	-	482 (0.4%)	0.1822	24 (0.2%)	412 (0.3%)	0.0336	527 (0.8%)	3348 (0.4%)	<0.0001
Peripheral vascular disease	121 (0.7%)	25977 (1.5%)	<0.0001	-	818 (0.8%)	0.0262	60 (0.4%)	1288 (0.9%)	<0.0001	1075 (1.7%)	9142 (1%)	<0.0001
Neurological disorders	514 (2.8%)	35792 (2.1%)	<0.0001	31 (2.8%)	2637 (2.5%)	0.4658	492 (3.6%)	2978 (2%)	<0.0001	3845 (6.1%)	21984 (2.4%)	<0.0001
Chronic pulmonary disease	754 (4.1%)	73501 (4.4%)	<0.0001	81 (7.3%)	8901 (8.3%)	0.2382	1074 (7.9%)	10288 (6.9%)	<0.0001	6658 (10.6%)	65697 (7.1%)	<0.0001
Diabetes	617 (3.3%)	105946 (6.3%)	<0.0001	71 (6.4%)	9448 (8.8%)	0.0051	900 (6.6%)	13133 (8.8%)	<0.0001	12308 (19.6%)	94501 (10.3%)	<0.0001
Hypothyroidism	154 (0.8%)	48717 (2.9%)	<0.0001	10 (0.9%)	1710 (1.6%)	0.0672	170 (1.3%)	3074 (2.1%)	<0.0001	2415 (3.8%)	20544 (2.2%)	<0.0001
Renal failure	132 (0.7%)	47014 (2.8%)	<0.0001	13 (1.2%)	2223 (2.1%)	0.0364	152 (1.1%)	3189 (2.1%)	<0.0001	3548 (5.7%)	23279 (2.5%)	<0.0001
Liver disease	327 (1.8%)	11604 (0.7%)	<0.0001	12 (1.1%)	825 (0.8%)	0.2341	326 (2.4%)	1189 (0.8%)	<0.0001	1581 (2.5%)	7174 (0.8%)	<0.0001
Peptic ulcer Disease, excluding bleeding	-	110 (0%)	0.4831	-	10 (0%)	0.748	-	-	0.2265	25 (0%)	71 (0%)	<0.0001
AIDS/HIV	53 (0.3%)	1251 (0.1%)	<0.0001	-	239 (0.2%)	0.7357	47 (0.3%)	192 (0.1%)	<0.0001	-	-	<0.0001
Cancer	57 (0.3%)	15369 (0.9%)	<0.0001	-	732 (0.7%)	0.84	62 (0.5%)	1169 (0.8%)	<0.0001	1397 (2.2%)	8866 (1%)	<0.0001
Rheumatoid arthritis/collagen vascular disease	23 (0.1%)	10629 (0.6%)	<0.0001	-	604 (0.6%)	0.195	49 (0.4%)	846 (0.6%)	0.0021	478 (0.8%)	5741 (0.6%)	<0.0001
Coagulopathy	282 (1.5%)	19811 (1.2%)	<0.0001	-	711 (0.7%)	0.8077	139 (1%)	947 (0.6%)	<0.0001	1397 (2.2%)	7296 (0.8%)	<0.0001
Obesity	316 (1.7%)	57061 (3.4%)	<0.0001	19 (1.7%)	2642 (2.5%)	0.1101	236 (1.7%)	3549 (2.4%)	<0.0001	4056 (6.5%)	27878 (3%)	<0.0001
Weight loss	176 (0.9%)	15196 (0.9%)	0.5567	-	365 (0.3%)	0.6932	79 (0.6%)	817 (0.5%)	0.581	1038 (1.7%)	6160 (0.7%)	<0.0001
Fluid and electrolyte dis orders	1097 (5.9%)	100558 (6%)	0.5985	57 (5.1%)	4573 (4.3%)	0.1475	671 (5%)	6304 (4.2%)	0.0001	7372 (11.7%)	38440 (4.2%)	<0.0001
Chronic blood loss anemia	26 (0.1%)	4482 (0.3%)	0.0008	-	166 (0.2%)	0.1902	13 (0.1%)	220 (0.1%)	0.1308	443 (0.7%)	1738 (0.2%)	<0.0001
Deficiency Anemias	606 (3.3%)	71713 (4.3%)	<0.0001	20 (1.8%)	2980 (2.8%)	0.0499	233 (1.7%)	3343 (2.2%)	<0.0001	5246 (8.4%)	27357 (3%)	<0.0001
Opioid Outcomes												
Opioid poisoning from primary diagnosis	203 (1.1%)	2796 (0.2%)	<0.0001	28 (2.5%)	497 (0.5%)	<0.0001	911 (6.7%)	900 (0.6%)	<0.0001	391 (0.6%)	1382 (0.1%)	<0.0001
Opioid poisoning	275 (1.5%)	3797 (0.2%)	<0.0001	38 (3.4%)	621 (0.6%)	<0.0001	1018 (7.5%)	1018 (0.7%)	<0.0001	498 (0.8%)	1734 (0.2%)	<0.0001
Heroin overdose	107 (0.6%)	761 (0%)	<0.0001	18 (1.6%)	323 (0.3%)	<0.0001	834 (6.2%)	775 (0.5%)	<0.0001	173 (0.3%)	774 (0.1%)	<0.0001
Prescription opioid overdose	179 (1%)	3103 (0.2%)	<0.0001	23 (2.1%)	327 (0.3%)	<0.0001	264 (1.9%)	285 (0.2%)	<0.0001	360 (0.6%)	1020 (0.1%)	<0.0001
Opioid-related visit	1748 (9.4%)	18819 (1.1%)	<0.0001	183 (16.5%)	4599 (4.3%)	<0.0001	3715 (27.4%)	4251 (2.8%)	<0.0001	5146 (8.2%)	15128 (1.6%)	<0.0001
Death from opioid poisoning	-	46 (0%)	0.0007	-	-	0.7881	12 (0.1%)	18 (0%)	<0.0001	14 (0%)	41 (0%)	<0.0001
Opioid-related death	-	88 (0%)	<0.0001	-	19 (0%)	0.6578	28 (0.2%)	33 (0%)	<0.0001	37 (0.1%)	111 (0%)	<0.0001

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Table 2.8. Comparison of adjusted and unadjusted opioid outcomes between homeless and low-income housed individuals in emergent care, stratified by state

		Unadjusted Risk		Unadjusted risk difference (95% CI)		Wald *P* value
		Homeless	Low-income Housed	Homeless vs. Low-income Housed	p-value	
Unadjusted Opioid-related Hospital Admission/ED	FL	9.41% (8.99% to 9.83%)	1.12% (1.11% to 1.14%)	8.29% (7.87% to 8.71%)	<0.001	<0.001
	MD	16.53% (14.34% to 18.72%)	4.29% (4.17% to 4.42%)	12.24% (10.05% to 14.43%)	<0.001	
	MA	27.42% (26.67% to 28.17%)	2.85% (2.76% to 2.93%)	24.57% (23.82% to 25.33%)	<0.001	
	NY	8.20% (7.99% to 8.42%)	1.65% (1.62% to 1.67%)	6.56% (6.34% to 6.77%)	<0.001	
Unadjusted Opioid Overdose	FL	1.49% (1.32% to 1.66%)	0.23% (0.22% to 0.24%)	1.26% (1.09% to 1.44%)	<0.001	<0.001
	MD	3.78% (2.60% to 4.96%)	0.59% (0.54% to 0.64%)	3.19% (2.01 to 4.37)	<0.001	
	MA	7.52% (7.08% to 7.97%)	0.68% (0.64% to 0.73%)	6.84% (6.39% to 7.29)	<0.001	
	NY	0.80% (0.73% to 0.87%)	0.19% (0.18% to 0.20%)	0.61% (0.54% to 0.68%)	<0.001	
		Adjusted Risk		Adjusted risk difference (95% CI)		Wald *P* value
		Homeless	Low-income Housed	Homeless vs. Low-income Housed	p-value	
Adjusted Opioid-related Hospital Admission/ED	FL	7.98% (7.23% to 8.73%)	1.13% (1.12% to 1.13%)	6.86% (6.09% to 7.62%)	<0.001	p<0.001
	MD	13.40% (9.33% to 17.46%)	4.36% (4.32% to 4.40%)	9.04% (4.79% to 13.28%)	<0.001	
	MA	24.06% (22.05% to 26.07%)	3.13% (2.95% to 3.31%)	20.93% (18.69% to 23.17%)	<0.001	
	NY	8.38% (6.78% to 9.98%)	1.63% (1.52% to 1.74%)	6.75% (5.02% to 8.47%)	<0.001	
Adjusted Opioid Overdose	FL	1.26% (1.05% to 1.48%)	0.23% (0.23% to 0.23%)	1.03% (0.81% to 1.25%)	<0.001	p<0.001
	MD	3.31% (2.19% to 4.44%)	0.60% (0.59% to 0.61%)	2.71% (1.54% to 3.89%)	<0.001	
	MA	6.43% (5.73% to 7.14%)	0.78% (0.72% to 0.84%)	5.65% (4.87% to 6.44%)	<0.001	
	NY	0.86% (0.65% to 1.08%)	0.19% (0.17% to 0.20%)	0.68% (0.45% to 0.91%)	<0.001	

CHAPTER III: FREQUENT EMERGENCY DEPARTMENT USE AMONG HOMELESS INDIVIDUALS: HIGH RISK OF OPIOID-RELATED DIAGNOSES AND ADVERSE HEALTH SERVICES UTILIZATION OUTCOMES

ABSTRACT

Background: Frequent use of emergent department (ED) by high-utilizers and homelessness are major public health issues in the United States.

Objective: To identify predictors of frequent ED use among the homeless population, and to compare frequent versus less frequent homeless ED users for their risk of serious health services utilization outcomes.

Design: Cross-sectional analysis

Participants: Based on the State Emergency Department Database and the State Inpatient Database, homeless individuals (n=88,541) who made at least one ED visit in four states (Florida, Maryland, Massachusetts, and New York) in 2014.

Main Measures: Patient-level demographic and clinical factors were assessed as predictors for increased ED use. Risks of opioid overdose, opioid-related hospital admission/ED visit, in-hospital mortality, mechanical ventilation, and hospitalizations were compared between individuals with ≥4 vs. 2-3 vs. 1 ED visit(s), adjusting for potential confounders including hospital fixed effects.

Key Results: Higher rates of ED use were associated with Medicare coverage under age 65; a primary diagnosis of alcohol abuse, asthma, or abdominal pain; and a co-morbidity of alcohol abuse, psychoses, or chronic pulmonary disease. Individuals with ≥4 visits had significantly higher adjusted risk of opioid overdose (3.7% vs. 1.2% vs. 1.0%; p-for-trend<0.001), opioid-related hospital admissions/ED visits (17.9% vs. 8.5% vs. 6.6%; p-for-trend<0.001), mechanical ventilation (9.8% vs. 7.0% vs. 4.7%; p-for-trend<0.001), and greater number of hospitalizations

(3.2 vs. 1.3 vs. 0.8; p-for-trend<0.001) compared to individuals with 2-3 or 1 ED visit. Individuals with ≥4 and 2-3 ED visits had similar but increased risks of in-hospital mortality compared to individuals with 1 ED visit (2.8% vs. 2.8% vs. 2.3%; p-for-trend<0.001).

Conclusions: Homeless patients who were high ED users were more likely to be hospitalized and have other adverse outcomes. These findings encourage targeted interventions for the high-utilizer homeless population to reduce the burden of serious outcomes and costs for the patient and society.

INTRODUCTION

Homelessness is a critical public health issue today in the United States, with an estimated 2.5 to 3.5 million Americans experiencing homelessness annually (National Coalition for the Homeless, 2009), and over 550,000 people homeless on any given night (Fazel et al., 2014; The US Department of Housing and Urban Development, 2018). Homeless individuals experience higher chronic and acute disease burdens (Bharel et al., 2013; Institute of Medicine Committee on Health Care for Homeless People, 1988), mortality rates that are 3.5 to 9 times that of the general population (Baggett et al., 2013; Hibbs et al., 1994) and are more likely to utilize costly emergency department and hospital inpatient services compared to housed individuals (Bharel et al., 2013; Kushel et al., 2002; Kushel et al., 2001).

Furthermore, frequent ED users, commonly defined as persons with 4 or more ED visits in a year (A. S. Hwang et al., 2015; Kanzaria et al., 2019; McConville, Raven, Sabbagh, & Hsia, 2018; B. C. Sun, Burstin, & Brennan, 2003), comprise a small proportion of all ED visitors, yet account for a disproportionate share of all ED visits (LaCalle & Rabin, 2010) and spending in the US (Ku et al., 2014; Mitchell, Leon, Byrne, Lin, & Bharel, 2017). Mental illness, substance use, and homelessness are consistently found to be major predictors of frequent ED use (Doran, Raven, & Rosenheck, 2013; Kanzaria et al., 2019; McConville et al., 2018). Most past studies have studied frequent ED utilizers among all patients who had an ED visit (Giannouchos, Washburn, Kum, Sage, & Ohsfeldt, 2019; A. S. Hwang et al., 2015; Kanzaria et al., 2019; Ruger, Richter, Spitznagel, & Lewis, 2004; B. C. Sun et al., 2003), not just the homeless. The few studies where frequent ED use was studied within the homeless population were restricted to a single hospital (Ku et al., 2014) or city (Kushel et al., 2002; Lin, Bharel, Zhang, O'Connell, & Clark, 2015; Mitchell et al., 2017; Thakarar, Morgan, Gaeta, Hohl, & Drainoni, 2015), or among

Veterans (Tsai & Rosenheck, 2013). Their generalizability to other geographic locations or populations remains unclear. To our knowledge, no studies have comprehensively studied homelessness at the regional or national level in relation to the frequency of ED visits and adverse health services utilization outcomes, such as opioid overdose.

To address these gaps, we used a large dataset that includes all hospital admissions and ED visits from four large and diverse states and examined the association between homeless individuals with varying levels of emergency department (ED) use and serious health services utilization outcomes, including opioid overdose. The results of this study can potentially have a meaningful impact on U.S. policies and practice for housing provision for the homeless population to reduce emergent care use and serious health services utilization outcomes.

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 (Healthcare Cost and Utilization Project (HCUP), 2018). The SID includes all inpatient discharge records from community hospitals (including emergency visits that result in hospitalization), and the SEDD includes the universe of 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 four states were selected because of the socio-demographic diversity of the population and the availability and completeness of the homeless indicator, which is reported directly from the hospitals (Healthcare Cost and Utilization Project (HCUP), 2008). For each inpatient and hospital-affiliated emergency department discharge, there is an indicator for each patient's homeless status. This indicator has previously been used in previous studies (Karaca et al., 2013; R. Sun et al., 2006; Wadhera, Choi, et al., 2019).

The study population was restricted to individuals who were classified as homeless and aged ≥18 years old, and had at least one ED visit in 2014. Since homeless status can shift across multiple ED visits, persons who were considered homeless during at least one visit were classified as homeless in this study. We excluded people 1) who had a primary diagnosis related to delivery (Clinical Classification Software single-level codes: 177-192, 194-196, 218-220, 222-224) since a large proportion of inpatient visits were delivery-related; and 2) people with missing data on the homeless indicator (5.6% of individuals in MA were missing) or any of the key variables used to construct the adjustment variables (i.e., patient identifier, primary diagnosis code, age, race/ethnicity, sex, and primary expected payer).

Primary exposure variable: Number of ED visits among ED visitors

The primary exposure, the number of ED visits among ED visitors, was categorized into whether or not the homeless individual had ≥4 ED visits, 2-3 ED visits or 1 ED visit during 2014. This split was used based on the distribution of the data: in 2014, 38.8% of ED visitors had ≥4 ED visits, 31.1% had 2-3 ED visits, and 30.1% had 1 ED visit(s). In the literature, frequent ED utilizers are most commonly classified as individuals with 4 or more visits in one year (Hunt, Weber, Showstack, Colby, & Callaham, 2006; A. S. Hwang et al., 2015; Kanzaria et al., 2019; Kushel et al., 2002; LaCalle & Rabin, 2010; McConville et al., 2018; B. C. Sun et al., 2003).

Outcome variables: health services utilization

The primary health services utilization outcomes for this individual-level analysis of ED visitors were (1) opioid overdose, (2) opioid-related hospital admission or ED visit, (3) in-hospital mortality, (4) mechanical ventilation as a measure of having had a near-fatal event, and (5) number of hospitalization(s). Outcome variables are defined in Table 3.1.

Adjustment variables

We adjusted for patient characteristics and hospital fixed effects. Patient characteristics included age (categorized as 18-34, 35-44, 45-55 and 65+), sex, race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic and Other (Asian/Pacific Islander, Native American, Other, Missing, Invalid, Unavailable from source)), primary insurance type (Medicare <65 (a proxy for disability), Medicare 65+, Medicaid, Private, Self-pay and No charge/Other), ten most common primary diagnoses using the Clinical Classification Software single-level codes (variable dxccs1), and 27 comorbidities included in the Elixhauser Comorbidities Index (Healthcare Cost and Utilization Project (HCUP), 2017) (excludes drug abuse in the opioid overdose and opioid-related hospital admission/ED visit analysis. AIDS and peptic ulcer disease were excluded because New York masks data elements for AIDS/HIV admissions, and there were <30 peptic ulcer cases per ED category). We also adjusted for hospital fixed effects, which account for both measured and unmeasured characteristics of hospitals that do not vary over time. Therefore, our models effectively compared homeless individuals with ≥4 vs. 2-3 vs. 1 ED visit(s) treated within the same hospital.

Statistical analysis

Baseline characteristics of the homeless patients were assessed using chi-squared tests for categorical predictors and Kruskal-Wallis tests for continuous predictors. We then used negative binomial regression model with hospital fixed effects to model patient demographic and clinical factors as predictors for increased ED use.

Next, we examined the association between ≥4, 2-3, and 1 ED use and health services utilization outcomes using multivariable regression models. We used multivariable linear probability models with Huber-White robust standard errors (to account for heteroscedasticity), as small cell sizes for some combinations of patient characteristics resulted in complete or quasi-complete separation in logistic regression models (Hellevik, 2009). The number of hospitalizations was modeled using a negative binomial regression model with hospital fixed effects, after testing for equidispersion and the Vuong test for zero-inflation.

After fitting the regression models, adjusted outcomes were calculated using the marginal standardization form of predictive margins. For each individual, we calculated predicted probabilities of each outcome with the categorical frequency of ED use fixed at each category and then averaged over the distribution of covariates in our sample (Williams, 2012).

All analyses were done in SAS Enterprise Guide 4.2 (SAS Institute) and Stata, version 14 (StataCorp). This study was approved by the institutional review board of the UCLA Office of the Human Research Protection Program (IRB #17-001758).

RESULTS

Overall, among 88,541 homeless individuals with at least one ED visit in 2014 across four states, 34,382 (38.8%) had ≥4 ED visits, 27,541 (31.1%) had 2-3 ED visits, and 26,618 (30.1%) individuals had 1 ED visit.

Predictors for ED use

In bivariate analysis, homeless individuals with ≥4 ED visits were more likely than individuals with 2-3 ED visits and 1 ED visit to be younger, male, non-Hispanic White, from FL or MA, have alcohol-related disorders, mood disorders, and substance-related disorders as their primary diagnosis, and similarly to have co-morbidities such as drug and alcohol abuse, psychoses and depression. They were less likely to have other medical chronic co-morbidities such as hypertension, diabetes, obesity, cancer, neurological disorders, and cardiovascular conditions compared to the individuals with 2-3 or 1 ED visits (Table 3.2).

In multivariable analysis, higher rates of ED use were associated with having Medicare coverage under age 65 compared to having Medicaid (IRR=1.17, 95%CI, 1.14 to 1.20), having alcohol-related disorders (IRR=1.54, 95%CI, 1.49 to 1.60), asthma (IRR=1.34, 95%CI, 1.28 to 1.41), and abdominal pain (IRR=1.33, 95%CI, 1.28 to 1.39) as a primary diagnosis, and having alcohol abuse (IRR=1.18, 95%CI, 1.15 to 1.22), psychoses (IRR=1.15, 95%CI, 1.11 to 1.19) and chronic pulmonary disorders (IRR=1.11, 95%CI, 1.08 to 1.14) as co-morbidities..

Lower rates of ED use were associated with being 55-64 years old (IRR=0.96, 95%CI, 0.94 to 0.99) or 65 years and older (IRR=0.80, 95%CI, 0.77 to 0.83) compared to being 18-34 years old, being female (IRR=0.96, 95%CI, 0.95 to 0.98) compared to being male, having private insurance (IRR=0.85, 95%CI, 0.81 to 0.88) or self-pay (IRR=0.88, 95%CI, 0.86 to 0.91) compared to having Medicaid, being Other race/ethnicity (IRR=0.77, 95%CI, 0.75 to 0.79), Hispanic (IRR=0.87, 95%CI, 0.85 to 0.89) or Non-Hispanic Black (IRR=0.95, 95%CI, 0.93 to 0.98) compared to being non-Hispanic White, and having chronic blood loss anemia (IRR=0.80, 95%CI, 0.74 to 0.88), weight loss (IRR=0.85, 95%CI, 0.80 to 0.90) or fluid and electrolyte disorders (IRR=0.86, 95%CI, 0.84 to 0.88) as co-morbidities (Table 3.3).

Association between the frequency of ED use and opioid-related outcomes

After adjusting for potential confounders (effectively comparing homeless individuals with ≥4 ED vs. 1 ED visit(s) and 2-3 ED vs. 1 ED visit(s) treated within the same hospital), homeless individuals with ≥4 ED visits had significantly higher risks of opioid overdose (adjusted risk, 3.7% for ≥4 ED visits vs. 1.2% for 2-3 ED visits vs. 1.0% for 1 ED visit, p-for-trend<0.001; adjusted risk difference (aRD), 2.6%; 95%CI, 1.8% to 3.4%; p<0.001 comparing ≥4 ED vs. 1 ED visit) and opioid-related hospital admission/ED visit (adjusted risk, 17.9% vs. 8.5% vs. 6.6%, p-for-trend<0.001; aRD, 11.3%; 95%CI, 9.3% to 10.3%; p<0.001) compared to individuals with 2-3 and 1 ED visit. Individuals with 2-3 ED visits had higher risk of opioid-related hospital admission/ED visits compared to individuals with 1 ED visit (aRD, 1.9%;95%CI, 1.2% to 2.6%; p<0.001 comparing 2-3 vs. 1 ED visit), but their risks were much smaller compared to those with ≥4 ED visits (Table 3.4).

Association between the frequency of ED use and hospitalization, mechanical ventilation and in-hospital mortality

Homeless individuals with ≥4 ED visits and 2-3 ED visits had a similar risk of in-hospital mortality, but both groups had higher in-hospital mortality risk compared to individuals with 1 visit (adjusted risk, 2.8% for ≥4 ED visits vs. 2.8% for 2-3 ED visits vs. 2.3% for 1 ED visit, p-for-trend<0.001). For mechanical ventilation events, homeless individuals with ≥4 ED visits had the highest risk, followed by individuals with 2-3 ED visits and 1 ED visit (adjusted risk, 9.8% for ≥4 ED visits vs. 7.0% for 2-3 ED visits vs. 4.7% for 1 ED visit, p-for-trend<0.001; aRD, 5.1%; 95%CI, 4.4% to 5.8%; p<0.001 comparing ≥4 vs. 1 ED visit and 2.3%; 95%CI, 1.9% to 2.8%; p<0.001 comparing ≥2-3 vs. 1 ED visit). Homeless patients with ≥4 ED visits had on average 3.2 hospitalizations compared to 1.3 for those with 2-3 ED visits and 0.8 for those with 1 ED visit (p-for-trend<0.001; aRD, 2.4 95%CI, 2.4 to 2.5; p<0.001 and aRD, 0.5, 95%CI, 0.5 to 0.5; p<0.001) (Table 3.4). Additionally, we found that ED use partially mediated the relationship between alcohol use, substance abuse, mental illness, and disability, and hospitalizations but this was not observed for the other outcomes.

DISCUSSION

In this analysis of a comprehensive dataset of all ED visitors from four large and diverse states, we had three major findings. First, we found higher rates of ED visits were associated with Medicare coverage under age 65 compared to Medicaid, a primary diagnosis of alcohol abuse, asthma, or abdominal pain, and a co-morbidity of alcohol abuse, psychoses, or chronic pulmonary disease.

Second, we found that higher ED use was associated with increased risk for opioid-related outcomes. Homeless individuals with 4 or more ED visits had significantly higher risks of opioid overdose and opioid-related hospital admissions/ED visits, compared to those with 2-3 ED visits and 1 ED visit.

Third, higher ED use was associated with increased risk for hospitalizations and mechanical ventilation events. Individuals with 4 or more ED visits had a significantly higher risk of mechanical ventilation and greater number of hospitalizations compared to patients with 2-3 and 1 ED visits, and those with 2-3 had higher risks than those with 1 ED visit. Both homeless individuals with 4 or more and those with 2-3 ED visits had much higher in-hospital mortality risk compared to homeless individuals with just 1 ED visit in 2014.

Homeless individuals with 4 or more ED visits had alarming opioid-related hospitalization/ED visit and overdose risks of 17.90% and 3.65%, respectively. The opioid crisis is a current public health emergency in the US, yet, very few studies have focused on the homeless population. One Boston study found that out of a third of the homeless patients younger than 45 years who died from a drug overdose, opioids were implicated in 81% of the deaths (Baggett et al., 2013). Both a New York City emergency department study (Doran et al., 2018), as well as a study among 250,000 veterans (24), found that homeless individuals have a higher risk for opioid use. Their high opioid overdose risk is at least contributed by their high barriers for accessing medication-assisted treatment (MAT) (Buzza, Elser, & Seal, 2019), and their rates of receipt of and adherence to MAT are moderate to low (Midboe et al., 2019; Parpouchi, Moniruzzaman, Rezansoff, Russolillo, & Somers, 2017). No studies have compared opioid outcomes across subgroups of the homeless population, one which could be meaningful when designing targeted interventions for MAT.

Further, we found that homeless individuals with frequent ED visits had higher risks of serious outcomes of their ED visit including in-hospital mortality, mechanical ventilation, and a greater number of hospitalizations. This is not surprising as researchers in the past have found that a small minority of the homeless population incurred a large majority of all hospitalization and ED visits (Hwang et al., 2013; Lin et al., 2015). Homeless individuals are more likely to use emergency department and inpatient services, have higher healthcare costs and have higher mortality rates compared to housed individuals (Bharel et al., 2013; Hwang et al., 2013). Other studies have quantified the mortality rate of homeless persons to be 3.5 to 9 times the general population (Baggett et al., 2013; Hibbs et al., 1994). No studies, to date, have compared these healthcare outcomes between frequent and less frequent ED department visitors.

This relationship that we found between ED use and adverse outcomes may not be causal but the underlying conditions and factors that increase ED use may also increase the risk for these outcomes. There are at least four possible explanations that explain this relationship. Homeless individuals who are higher ED utilizers may have 1) a higher burden of disease (Bharel et al., 2013; Institute of Medicine Committee on Health Care for Homeless People, 1988) 2) individual circumstances which make it more difficult to manage their burden of disease (Gelberg et al., 1997) 3) specific conditions which increase their risk for ED use (Bharel et al., 2013), and/or 4) disparities in receipt of hospital-based care (Wadhera, Khatana, et al., 2019). The results suggest that homeless persons who are frequent ED visitors bear a heavy medical burden, which results in high costs. Temporary treatment for alcohol, substance abuse, and psychiatric disorders at emergency and inpatient hospitals is not an effective approach for high-quality care or long-term cost-savings. These individuals will continue to return to the ED if the underlying cause of the ED visit is not addressed.

Results from interventions to improve the health, housing status, and ED and inpatient utilization costs of the homeless have been promising overall (Miller-Archie, Walters, Singh, & Lim, 2019; Wright, Vartanian, Li, Royal, & Matson, 2016). Housing First has been a well-adopted model for housing provision and has been studied to achieve an annual per-person cost savings of $6,307. The program places homeless individuals immediately into permanent housing without contingencies for psychiatric treatment or sobriety. It has been studied to be more effective than other programs that require stringent prerequisites for housing (Tsemberis et al., 2004). Given the limitation in resources, Housing First programs may want to focus their outreach and efforts on these high-risk homeless individuals – these individuals who return to the ED much more frequently.

Our study has limitations. First, as this is a cross-sectional analysis, the temporal relationship between exposure and outcome could not be assessed; therefore, we are not able to rule out the possibility of reverse causation. Second, the quality and completeness of the homeless indicator cannot be verified; however, this indicator has been used in previous studies (Karaca et al., 2013; R. Sun et al., 2006; Wadhera, Choi, et al., 2019) and the homeless count for MA and NY have been consistent with point-in-time estimates published by the Department of Housing and Urban Development (U.S. Department of Housing and Urban Development, 2014). Homeless status in our data is collected by hospitals, and hospitals have strong financial incentives associated with billing and collection to accurately determine where the patient lives. Third, exposure and outcome misclassification could bias our true estimates. We tried to minimize this by defining the exposure and selecting outcomes that have been previously defined in prior studies. Furthermore, homelessness is a dynamic status, and we are not able to capture the severity of homelessness in our data. Fourth, the SID/SEDD database captures only homeless individuals who had at least one ED visit in non-federal community hospitals in 2014, and therefore, our findings may not be generalizable to healthier or sicker homeless individuals who had no encounter in the ED or had an encounter in an ED not captured by our data in a given year. Lastly, although we used all ED discharge data from four large and diverse states, our findings may not be generalizable to homeless patients in other states, not included in our data.

CONCLUSION

Among homeless individuals who had at least one ED visit, there are demographic and clinical factors associated with frequent ED use. Individuals with ≥4 ED visits in 2014 had much higher adverse health services utilization outcomes, including opioid overdose, mechanical ventilation, and hospitalizations compared to individuals with 2-3 and 1 ED. In-hospital mortality risk, however, was increased after the first ED visit. Our research suggests that interventions specifically targeting homeless persons who are frequent ED utilizers may be a cost-effective approach for allocating limited resources to alleviate the healthcare burden of this population, perhaps by providing them with housing, since “Housing is Health,” using a Housing First model. Some health care systems are looking into this approach of EDs addressing social determinants of health in the ED to benefit the patients, reduce avoidable ED visits, and reduce costs (Ronald O. Perelman Department of Emergency Department).

Table 3.1. Definition of Outcomes

Outcome	Definition
Opioid-related hospital admission/ED visit	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 in first 10 diagnosis codes across all hospital admissions and ED visits
Opioid overdose	ICD-9 Codes: 965.00 – 965.02, 965.09, E850.0 – E850.2 in first 10 diagnosis codes across all hospital admissions and ED visits
In-hospital mortality	Any all-cause death that occurred during ED visits or hospitalizations in 2014
Mechanical ventilation	HCUP Clinical Classification Software procedure code 216 in first 14 procedure codes across all hospital admissions and ED visits
Hospitalizations	Any hospital admissions regardless of whether patients were admitted from the ED during 2014

ED = Emergency Department; HCUP = Healthcare Cost and Utilization Project; ICD-9 = International Classification of Disease, Ninth Revision

Table 3.2. Characteristics of homeless individuals with 4+, 2-3, or 1 emergency department (ED) visit in 2014, by number of ED visits

	1 ED Visit (N=26,618)	2-3 ED Visit (N=27,541)	4+ ED Visit (N=34,382)	Total (88,541)	p value
Age in years at time of ED visit					<0.0001
18-34	6,633 (24.9%)	8,310 (30.2%)	10,817 (31.5%)	25,760 (29.1%)	
35-44	3,798 (14.3%)	4,183 (15.2%)	6,087 (17.7%)	14,068 (15.9%)	
45-54	5,087 (19.1%)	5,349 (19.4%)	8,475 (24.7%)	18,911 (21.4%)	
55-64	4,621 (17.4%)	4,518 (16.4%)	5,607 (16.3%)	14,746 (16.7%)	
65+	6,479 (24.3%)	5,181 (18.8%)	3,396 (9.9%)	15,056 (17%)	
Sex					<0.0001
Female	11,804 (44.3%)	12,880 (46.8%)	13,756 (40%)	38,440 (43.4%)	
Primary expected payer					<0.0001
Medicaid	14370 (54%)	14090 (51.2%)	17591 (51.2%)	4,6051 (52%)	
Medicare, <65 year-olds	1,699 (6.4%)	2,022 (7.3%)	4,326 (12.6%)	8,047 (9.1%)	
Medicare, 65+ year-olds	4,852 (18.2%)	3,934 (14.3%)	2,700 (7.9%)	11,486 (13.0%)	
Private insurance	1,011 (3.8%)	1,155 (4.2%)	1,458 (4.2%)	3,624 (4.1%)	
Self-pay	3,731 (14%)	5,202 (18.9%)	6,245 (18.2%)	15,178 (17.1%)	
No charge/Other	955 (3.6%)	1,138 (4.1%)	2,062 (6%)	4,155 (4.7%)	
Race/ Ethnicity					<0.0001
Non-Hispanic White	7,634 (28.7%)	8,128 (29.5%)	13,809 (40.2%)	29,571 (33.4%)	
Non-Hispanic Black	7,461 (28%)	8,551 (31%)	10,619 (30.9%)	26,631 (30.1%)	
Hispanic	6,921 (26%)	6,924 (25.1%)	6,888 (20%)	20,733 (23.4%)	
Other	4,602 (17.3%)	3,938 (14.3%)	3,066 (8.9%)	11,606 (13.1%)	
Top ten most prevalent primary diagnosis					
Alcohol-related disorders	1,109 (4.2%)	1,173 (4.3%)	3,020 (8.8%)	5,302 (6%)	<0.0001
Mood disorders	1,277 (4.8%)	1,326 (4.8%)	2,391 (7%)	4,994 (5.6%)	<0.0001
Schizophrenia and other psychotic disorders	1,861 (7%)	1,670 (6.1%)	2,336 (6.8%)	5,867 (6.6%)	<0.0001
Substance-related disorders	775 (2.9%)	827 (3%)	1,512 (4.4%)	3,114 (3.5%)	<0.0001
Abdominal pain	231 (0.9%)	908 (3.3%)	1,209 (3.5%)	2,348 (2.7%)	<0.0001
Nonspecific chest pain	836 (3.1%)	833 (3%)	1,079 (3.1%)	2,748 (3.1%)	0.6599
Asthma	479 (1.8%)	594 (2.2%)	889 (2.6%)	1,962 (2.2%)	<0.0001

Spondylosis; intervertebral disc disorders	299 (1.1%)	608 (2.2%)	805 (2.3%)	1,712 (1.9%)	<0.0001
Superficial injury; contusion	464 (1.7%)	538 (2%)	780 (2.3%)	1,782 (2%)	<0.0001
Essential hypertension	216 (0.8%)	255 (0.9%)	251 (0.7%)	722 (0.8%)	0.0265
Total # of Elixhauser conditions					<0.0001
Mean (SD)	1.5 (1.63)	1.1 (1.55)	1.1 (1.53)	1.2 (1.6)	
Median	1.0 (0.0, 2.0)	0.0 (0.0, 2.0)	0.0 (0.0, 2.0)	1.0 (0.0, 2.0)	
Elixhauser co-morbidities					
Hypertension	9,003 (33.8%)	6,896 (25%)	6,756 (19.6%)	22655 (25.6%)	<0.0001
Drug abuse	2,271 (8.5%)	2,190 (8%)	3,910 (11.4%)	8371 (9.5%)	<0.0001
Diabetes	4,855 (18.2%)	3,884 (14.1%)	3,798 (11%)	12537 (14.2%)	<0.0001
Alcohol abuse	2,067 (7.8%)	1,715 (6.2%)	3,181 (9.3%)	6963 (7.9%)	<0.0001
Chronic pulmonary disease	2,515 (9.4%)	2,252 (8.2%)	3,075 (8.9%)	7842 (8.9%)	<0.0001
Fluid and electrolyte disorders	3,928 (14.8%)	2,534 (9.2%)	2,349 (6.8%)	8811 (10%)	<0.0001
Psychoses	1,147 (4.3%)	1,116 (4.1%)	2,284 (6.6%)	4547 (5.1%)	<0.0001
Depression	1,160 (4.4%)	1,022 (3.7%)	1,782 (5.2%)	3964 (4.5%)	<0.0001
Neurological disorders	1,721 (6.5%)	1,222 (4.4%)	1,649 (4.8%)	4592 (5.2%)	<0.0001
Deficiency Anemias	2,306 (8.7%)	1,634 (5.9%)	1,617 (4.7%)	5557 (6.3%)	<0.0001
Obesity	1,753 (6.6%)	1,248 (4.5%)	1,201 (3.5%)	4202 (4.7%)	<0.0001
Renal failure	1,334 (5%)	1,186 (4.3%)	1,091 (3.2%)	3611 (4.1%)	<0.0001
Liver disease	694 (2.6%)	504 (1.8%)	872 (2.5%)	2070 (2.3%)	<0.0001
Congestive heart failure	932 (3.5%)	727 (2.6%)	677 (2%)	2336 (2.6%)	<0.0001
Hypothyroidism	1,157 (4.3%)	688 (2.5%)	618 (1.8%)	2463 (2.8%)	<0.0001
Coagulopathy	718 (2.7%)	484 (1.8%)	519 (1.5%)	1721 (1.9%)	<0.0001
Peripheral vascular disease	439 (1.6%)	367 (1.3%)	342 (1%)	1148 (1.3%)	<0.0001
Cancer	549 (2.1%)	463 (1.7%)	294 (0.9%)	1306 (1.5%)	<0.0001
Weight loss	554 (2.1%)	364 (1.3%)	307 (0.9%)	1225 (1.4%)	<0.0001
Valvular disease	310 (1.2%)	238 (0.9%)	187 (0.5%)	735 (0.8%)	<0.0001
Pulmonary circulation disease	216 (0.8%)	187 (0.7%)	146 (0.4%)	549 (0.6%)	<0.0001
Rheumatoid arthritis/collagen vascular disease	196 (0.7%)	151 (0.5%)	149 (0.4%)	496 (0.6%)	<0.0001
Chronic blood loss anemia	209 (0.8%)	138 (0.5%)	91 (0.3%)	438 (0.5%)	<0.0001

Table 3.3. Negative Binomial Regression Results of # of Emergency Department visits on Selected Covariates

Predictors	IRR	p-value
Age categories		
18 – 34	Reference	
35-44	1.02 (1.00 to 1.04)	0.1
45-54	1.05 (1.03 to 1.07)	<0.0001
55-64	0.96 (0.94 to 0.99)	<0.01
65+	0.80 (0.77 to 0.83)	<0.0001
Sex		
Female	0.96 (0.95 to 0.98)	<0.0001
Male	Reference	
Primary expected payer		
Medicaid	Reference	
Medicare, <65 year olds	1.17 (1.14 to 1.20)	<0.0001
Medicare, 65+ year olds	0.98 (0.94 to 1.01)	0.22
Private insurance	0.85 (0.81 to 0.88)	<0.0001
Self-pay	0.88 (0.86 to 0.91)	<0.0001
No charge/Other	0.98 (0.94 to 1.01)	0.21
Race/ethnicity		
Non-Hispanic White	Reference	
Non-Hispanic Black	0.95 (0.93 to 0.98)	<0.0001
Hispanic	0.87 (0.85 to 0.89)	<0.0001
Other	0.77 (0.75 to 0.79)	<0.0001
Top ten most prevalent primary diagnosis		
Alcohol-related disorders	1.54 (1.49 to 1.60)	<0.0001
Schizophrenia and other psychotic disorders	1.07 (1.04 to 1.11)	<0.0001
Mood disorders	1.13 (1.09 to 1.17)	<0.0001
Substance-related disorders	1.08 (1.03 to 1.12)	<0.01
Nonspecific chest pain	1.18 (1.13 to 1.23)	<0.0001
Abdominal pain	1.33 (1.28 to 1.39)	<0.0001
Essential hypertension	0.98 (0.91 to 1.06)	0.59
Asthma	1.34 (1.28 to 1.41)	<0.0001
Spondylosis; intervertebral disc disorder	1.16 (1.10 to 1.22)	<0.0001
Superficial injury; contusion	1.01 (0.96 to 1.06)	0.74
Selected Elixhauser co-morbidities		
Alcohol abuse	1.18 (1.15 to 1.22)	<0.0001
Drug abuse	1.05 (1.03 to 1.08)	<0.0001
Psychoses	1.15 (1.11 to 1.19)	<0.0001
Depression	1.06 (1.02 to 1.09)	<0.01
Hypertension	0.93 (0.91 to 0.95)	<0.0001

Neurological disorders	1.05 (1.02 to 1.09)	<0.01
Chronic pulmonary disease	1.11 (1.08 to 1.14)	<0.0001
Hypothyroidism	0.90 (0.86 to 0.95)	<0.0001
Renal failure	1.09 (1.05 to 1.13)	<0.0001
Cancer	0.88 (0.84 to 0.93)	<0.0001
Coagulopathy	0.90 (0.85 to 0.95)	<0.0001
Obesity	0.90 (0.87 to 0.93)	<0.0001
Weight loss	0.85 (0.80 to 0.90)	<0.0001
Fluid and electrolyte disorders	0.86 (0.84 to 0.88)	<0.0001
Chronic blood loss anemia	0.80 (0.74 to 0.88)	<0.0001
Liver disease	1.07 (1.02 to 1.13)	<0.01
Congestive heart failure	1.03 (0.98 to 1.08)	0.19
Valvular disease	0.95 (0.89 to 1.02)	0.19
Pulmonary circulation disease	1.00 (0.92 to 1.09)	1.00
Perivascular disease	1.01 (0.94 to 1.08)	0.80
Diabetes	0.99 (0.97 to 1.02)	0.59
Rheumatoid arthritis/collagen vascular disease	1.00 (0.91 to 1.09)	0.98
Deficiency Anemias	0.97 (0.94 to 1.01)	0.10

Table 3.4. Comparison of adjusted outcomes for homeless individuals with 1, 2-3 and 4+ Emergency Department visits (individual level) and hospital fixed effect

	Adjusted outcomes			Adjusted risk difference (95% CI)		Adjusted risk difference (95% CI)	
Outcome	1 visit	2-3 visits	4+ visits	2-3 versus 1	p-value	4+ versus 1	p-value
# of Hospitalization(s)	0.79 (0.78 to 0.80)	1.30 (1.29 to 1.31)	3.22 (3.19 to 3.26)	+0.51 (0.49 to 0.52)	<0.001	+2.43 (2.40 to 2.47)	<0.001
In-Hospital Mortality	2.33% (2.20% to 2.45%)	2.79% (2.62% to 2.97%)	2.80% (2.63% to 2.97%)	+0.47% (0.25% to 0.68%)	<0.001	+0.48% (0.21% to 0.74%)	<0.001
Mechanical Ventilation	4.69% (4.32% to 5.06%)	7.02% (6.73% to 7.31%)	9.82% (9.45% to 10.19%)	+2.33% (1.86% to 2.80%)	<0.001	+5.13% (4.44% to 5.83%)	<0.001
Opioid Overdose	1.04% (0.69% to 1.38%)	1.21% (0.93% to 1.49%)	3.65% (3.18% to 4.11%)	+0.17% (-0.03% to 0.38%)	0.098	+2.61% (1.81% to 3.41%)	<0.001
Opioid-related Hospital Admission/ED visit	6.59% (5.63% to 7.56%)	8.50% (7.98% to 9.02%)	17.90% (16.82% to 18.98%)	+1.91% (1.20% to 2.62%)	<0.001	+11.30% (9.27% to 13.33%)	<0.001

N=88,541
Multivariable regression model adjusts for age, sex, primary expected payer, top ten most prevalent primary diagnoses, and Elixhauser co-morbidities
ED = Emergency Department; CI = Confidence Interval

Appendix

Table 3.1. Characteristics of homeless individuals with at least 1 ED visit in 2014 by State

	FL (N=18764)	MA (N=14183)	MD (N=1307)	NY (N=59905)	p value
4+ ED visits vs. 1-3 ED visits					<0.0001
1-3 ED visit	10207 (54.4%)	6539 (46.1%)	601 (46%)	40923 (68.3%)	
4+ ED visit	8557 (45.6%)	7644 (53.9%)	706 (54%)	18982 (31.7%)	
Age in years at admission					<0.0001
Median	45	42	43	50	
Sex					<0.0001
Male	13458 (71.7%)	9554 (67.4%)	947 (72.5%)	28979 (48.4%)	
Female	5306 (28.3%)	4629 (32.6%)	360 (27.5%)	30926 (51.6%)	
Primary expected payer					<0.0001
Medicaid	3031 (16.2%)	7417 (52.3%)	617 (47.2%)	38073 (63.6%)	
Medicare	2568 (13.7%)	2992 (21.1%)	175 (13.4%)	15066 (25.1%)	
Private insurance	895 (4.8%)	1578 (11.1%)	67 (5.1%)	1290 (2.2%)	
Self-pay	10010 (53.3%)	749 (5.3%)	346 (26.5%)	5016 (8.4%)	
No charge/Other	2260 (12%)	1447 (10.2%)	102 (7.8%)	460 (0.8%)	
Race/ethnicity					<0.0001
Non-Hispanic White	12250 (65.3%)	9235 (65.1%)	511 (39.1%)	8530 (14.2%)	
Non-Hispanic Black	3721 (19.8%)	2555 (18%)	596 (45.6%)	21692 (36.2%)	
Hispanic	2355 (12.6%)	2054 (14.5%)	130 (9.9%)	17821 (29.7%)	
Other	438 (2.3%)	339 (2.4%)	70 (5.4%)	11862 (19.8%)	
Top ten most prevalent primary dx among homeless					<0.0001
Alcohol-related disorders	1502 (8%)	1324 (9.3%)	151 (11.6%)	2581 (4.3%)	
Schizophrenia and other psychotic disord ers	1192 (6.4%)	360 (2.5%)	68 (5.2%)	4522 (7.5%)	
Mood disorders	1434 (7.6%)	1171 (8.3%)	115 (8.8%)	2565 (4.3%)	
Substance-related disorders	511 (2.7%)	1066 (7.5%)	43 (3.3%)	1710 (2.9%)	
Nonspecific chest pain	706 (3.8%)	283 (2%)	56 (4.3%)	1918 (3.2%)	
Abdominal pain	517 (2.8%)	358 (2.5%)	34 (2.6%)	1627 (2.7%)	
Essential hypertension	150 (0.8%)	54 (0.4%)	14 (1.1%)	562 (0.9%)	
Asthma	151 (0.8%)	178 (1.3%)	21 (1.6%)	1691 (2.8%)	
Spondylosis; intervertebral disc disorders	482 (2.6%)	424 (3%)	31 (2.4%)	945 (1.6%)	
Superficial injury; contusion	761 (4.1%)	505 (3.6%)	50 (3.8%)	545 (0.9%)	
Other	11358 (60.5%)	8460 (59.6%)	724 (55.4%)	41239 (68.8%)	
Selected Elixhauser co-morbidities					
Alcohol abuse	1338 (7.1%)	1578 (11.1%)	171 (13.1%)	4133 (6.9%)	<0.0001
Drug abuse	1310 (7%)	2010 (14.2%)	157 (12%)	5256 (8.8%)	<0.0001
Psychoses	639 (3.4%)	1138 (8%)	95 (7.3%)	2892 (4.8%)	<0.0001
Depression	481 (2.6%)	1095 (7.7%)	67 (5.1%)	2507 (4.2%)	<0.0001
Hypertension	1709 (9.1%)	1951 (13.8%)	214 (16.4%)	20132 (33.6%)	<0.0001
Congestive heart failure	109 (0.6%)	117 (0.8%)	14 (1.1%)	2199 (3.7%)	<0.0001
Neurological disorders	522 (2.8%)	512 (3.6%)	47 (3.6%)	3696 (6.2%)	<0.0001
Chronic pulmonary disease	745 (4%)	1108 (7.8%)	105 (8%)	6351 (10.6%)	<0.0001
Diabetes	616 (3.3%)	934 (6.6%)	91 (7%)	11632 (19.4%)	<0.0001
Renal failure	130 (0.7%)	154 (1.1%)	20 (1.5%)	3446 (5.8%)	<0.0001
Liver disease	327 (1.7%)	343 (2.4%)	21 (1.6%)	1477 (2.5%)	<0.0001
Cancer	57 (0.3%)	60 (0.4%)	7 (0.5%)	1284 (2.1%)	<0.0001

Table 3.2. Serious health services utilization outcomes comparing frequent ED (4+) users compared to less frequent (1-3) users by State, adjusted for covariates and hospital fixed effects

		Adjusted outcomes		Adjusted risk difference (95% CI)		Wald P-value
		4+ visits	1-3 visits	4+ versus 1-3	P-value	
Opioid poisoning	FL	2.27% (2.08% to 2.46%)	0.83% (0.67% to 0.99%)	+1.44% (1.09% to 1.80%)	<0.001	<0.001
	MD	5.63% (4.91% to 6.34%)	1.23% (0.39% to 2.07%)	+4.4% (2.80% to 6.00%)	<0.001	
	MA	11.09% (10.59% to 11.58%)	3.41% (2.83% to 3.98%)	+7.68% (6.59% to 8.77%)	<0.001	
	NY	1.49% (1.27% to 1.71%)	0.54% (0.44% to 0.65%)	+0.94% (0.62% to 1.28%)	<0.001	
In-hospital mortality	FL	0.96% (0.76% to 1.16%)	1.23% (1.07% to 1.40%)	-0.27% (-0.64% to 0.09%)	0.15	0.0007
	MD	0.60% (-0.09% to 1.29%)	1.64% (0.82% to 2.45%)	-1.04% (-2.59% to 0.51%)	0.18	
	MA	2.10% (1.86% to 2.35%)	1.15% (0.86% to 1.43%)	+0.96% (0.42% to 1.49%)	0.001	
	NY	3.46% (3.20% to 3.73%)	3.25% (3.13% to 3.38%)	+0.21% (-0.19% to 0.61%)	0.29	
Near-death event	FL	4.89% (4.55% to 5.22%)	2.46% (2.18% to 2.75%)	+2.42% (1.80% to 3.05%)	<0.001	0.0058
	MD	6.79% (5.98% to 7.61%)	1.86% (0.90% to 2.82%)	+4.94% (3.11% to 6.77%)	<0.001	
	MA	5.64% (5.28% to 5.99%)	2.31% (1.90% to 2.72%)	+3.33% (2.55% to 4.11%)	<0.001	
	NY	12.12% (11.56% to 12.69%)	7.99% (7.72% to 8.25%)	+4.13% (3.29% to 4.97%)	<0.001	
Hospitalization (dichotomous)	FL	71.56% (70.39% to 72.73%)	39.48% (38.50% to 40.46%)	+32.07% (29.91% to 34.24%)	<0.001	<0.001
	MD	67.28% (65.17% to 69.39%)	29.38% (26.89% to 31.87%)	+37.90% (33.16% to 42.65%)	<0.001	
	MA	62.13% (61.34% to 62.93%)	30.58% (29.65% to 31.51%)	+31.55% (29.79% to 33.31%)	<0.001	
	NY	99.83% (99.00% to 100.01%)	98.27% (97.88% to 98.65%)	+1.56% (0.35% to 2.78%)	0.012	

*Multivariable model adjusts for age (categories), sex, primary expected payer, race/ethnicity, top ten primary diagnosis, Elixhauser co-morbidities and hospital ID

Table 3.3. Serious health services utilization outcomes comparing frequent ED (4+) users compared to less frequent (1-3) users by Race, adjusted for covariates and hospital fixed effects

		Adjusted outcomes		Adjusted risk difference (95% CI)		Wald P-value
		4+ visits	1-3 visits	4+ versus 1-3	P-value	
Opioid poisoning	White	6.78% (6.27% to 7.29%)	2.28% (1.84% to 2.73%)	+4.50% (3.54% to 5.45%)	<0.001	<0.001
	Black	1.07% (0.88% to 1.27%)	0.46% (0.33% to 0.58%)	+0.62% (0.29% to 0.94%)	<0.001	
	Hispanic	2.41% (1.86% to 2.96%)	0.72% (0.46% to 0.99%)	+1.69% (0.87% to 2.51%)	<0.001	
	Other	1.39% (0.98% to 1.79%)	0.41% (0.27% to 0.55%)	+0.98% (0.43% to 1.52%)	<0.001	
In-hospital mortality	White	2.88% (2.57% to 3.19%)	2.60% (2.33% to 2.86%)	+0.28% (-0.30% to 0.86%)	0.341	0.0005
	Black	2.42% (2.20% to 2.63%)	2.42% (2.28% to 2.56%)	-0.01% (-0.37% to 0.35%)	0.971	
	Hispanic	2.77% (2.47% to 3.06%)	2.11% (1.97% to 2.25%)	+0.65% (0.22% to 1.09%)	0.003	
	Other	3.25% (2.70% to 3.81%)	3.17% (2.98% to 3.37%)	+0.08% (-0.68% to 0.84%)	0.836	
Near-death event	White	8.56% (8.13% to 8.99%)	4.86% (4.49% to 5.24%)	+3.69% (2.89% to 4.50%)	<0.001	0.2123
	Black	10.00% (9.44% to 10.56%)	6.39% (6.03% to 6.75%)	+3.61% (2.68% to 4.54%)	<0.001	
	Hispanic	10.08% (9.36% to 10.80%)	5.90 (5.55% to 6.24%)	+4.18% (3.12% to 5.25%)	<0.001	
	Other	10.11% (9.26% to 10.96%)	7.35% (7.06% to 7.65%)	+2.75% (1.60% to 3.90%)	<0.001	
hospitalization (dichotomous)	White	79.86% (77.68% to 82.04%)	52.99% (51.09% to 54.88%)	+26.87% (22.79% to 30.95%)	<0.001	<0.001
	Black	92.52% (89.74% to 95.30%)	82.56% (80.77% to 84.35%)	+9.96% (5.37% to 14.55%)	<0.001	
	Hispanic	95.30% (91.91% to 98.68%)	85.91% (84.29% to 87.53%)	+9.39% (4.36% to 14.41%)	0.001	
	Other	98.52% (96.94% to 100.00%)	94.72% (94.17% to 95.26%)	+3.80% (1.66% to 5.93%)	<0.001	

*Multivariable model adjusts for age (categories), sex, primary expected payer, top ten primary diagnosis, Elixhauser co-morbidities and hospital ID

CHAPTER IV: ASSOCIATION BETWEEN HOMELESSNESS AND DELIVERY HOSPITALIZATION OUTCOMES: A MULTI-STATE POPULATION-BASED STUDY

ABSTRACT

Background: Women and families comprise the fastest-growing segments of the homeless population. However, evidence is limited as to whether pregnant homeless women experience worse childbirth delivery outcomes compared to non-homeless pregnant women.

Objective: To investigate whether homeless pregnant women who had a childbirth delivery admission exhibit worse outcomes compared to non-homeless women.

Design, Setting, and Participants: Using large, state-wide databases that include all hospital admissions in three states (Florida, Massachusetts, and New York) in 2014, we compared childbirth delivery outcomes between homeless versus non-homeless women aged 18-44 years.

Measurements: Outcome variables included: (1) obstetric complications (antepartum hemorrhage, placental abnormalities, premature rupture of the membranes, preterm labor, postpartum hemorrhage), (2) neonatal complications (fetal distress, fetal growth restriction, stillbirth), (3) delivery method (cesarean section [C-section]), and (4) delivery-related costs. We adjusted for patient-level confounders using overlap propensity score weights. We analyzed both without hospital fixed effects (comparing patients across hospitals) and with hospital fixed effects (effectively comparing patients within the same hospital).

Results: A total of 15,029 homeless and 308,242 non-homeless women were included. In the analysis comparing patients across hospitals, we found that homeless women had a lower C-section rate (adjusted rate, 31.8% for homeless vs. 36.1% for non-homeless women; adjusted risk difference [aRD], -4.3%; 95%CI, -6.9% to -1.8%; p=0.01) and a higher risk of fetal distress (23.4% vs. 19.2%; aRD, +4.2%; 95%CI, +1.3% to +7.0%; p=0.02). When we compared patients within the same hospital, we found that homeless women were more likely to experience preterm labor (10.5% vs. 6.7%; aRD, +3.8%; 95%CI, +1.2% to +6.5%; p=0.03), placental abnormalities (4.0% vs. 2.0%; aRD, +1.9%; 95%CI, +0.4% to +3.5%; p=0.05), and higher delivery-related costs ($5,970 vs. $5,420; aRD, +$550; 95%CI, +$168 to +$931; p=0.03) compared to non-homeless women.

Conclusions: Compared to non-homeless pregnant women who had a delivery, homeless women who were admitted to the same hospital were more likely to experience childbirth delivery complications and higher delivery-related. These findings suggest that policies should encourage healthcare providers to screen pregnant women for social needs and collaborate with social housing programs and ensuring their healthcare needs are met, including their social needs.

INTRODUCTION

Over 560,000 Americans are homeless on any given night,(U.S. Department of Housing and Urban Development, 2019) and each year, about 1% of the U.S. population experience homelessness. (National Coalition for the Homeless, 2009) Homelessness has been on the rise in metropolitan cities in recent years,(U.S. Department of Housing and Urban Development, 2019) and is a concern that has attracted attention for funding for housing initiatives both at the local and national levels. (City of Los Angeles; National Alliance to End Homelessness, 2020) Individuals who are unstably housed or homeless have higher disease burdens, mortality rates, and healthcare spending that is 2.5 times that of a comparable housed population. (Baggett et al., 2013; Bharel et al., 2013; Institute of Medicine Committee on Health Care for Homeless People, 1988; Koh et al., 2020; Kushel et al., 2002; Kushel et al., 2001) Healthcare for the treatment of homeless patients has become a major public health issue.

While the majority of homeless individuals are men, approximately one in four homeless individuals are women and girls (U.S. Department of Housing and Urban Development, 2019), and women and families comprise the fastest-growing segment of the homeless population. (Welch-Lazoritz et al., 2015) Pregnant women are in particular need of routine medical care and consistent monitoring during their pregnancy to ensure the safe delivery of the infant. Circumstances associated with homelessness, such as malnutrition, pre-existing conditions, including substance abuse and mental illness, affect the health of both the mother and the fetus. (Beal & Redlener, 1995; Killion, 1995) Homeless women tend to live in dire living situations which pose additional challenges that limit their ability to take care of their health or seek care. (Stein, Andersen, & Gelberg, 2007)

Evidence is limited as to whether homeless pregnant women experience worse childbirth-related outcomes compared with non-homeless women. Existing research suggests that homeless women have barriers accessing prenatal care,(Bloom et al., 2004) fewer prenatal care visits (Richards et al., 2011) and have a higher likelihood of experiencing adverse birth outcomes, including preterm birth, low birthweight infants, small for gestational age infants, admissions to neonatal intensive care, and longer lengths of stays for the infant. (Little et al., 2005; Richards et al., 2011; Stein et al., 2000) However, these studies were limited as they were small studies conducted in a single hospital,(Little et al., 2005; Paterson & Roderick, 1990) city (Los Angeles),(Stein et al., 2000) or state (Massachusetts),(Clark et al., 2019) and therefore, whether their findings were generalizable to the homeless population living in other regions remains unclear. Given an increasing number of homeless pregnant women in metropolitan areas, and widely-discussed concerns about their health outcomes,(Shaban et al., 2017) empirical evidence about the health outcomes of the homeless pregnant women using population-based data from multiple states is critically important.

In this context, using state-wide databases that include all hospital discharges from three large and diverse states, we examined the association between homelessness and obstetric, neonatal, and health services outcomes among all pregnant women who had a delivery hospitalization in 2014.

METHODS

Data Sources and Study Sample

We analyzed the 2014 State Inpatient Database (SID) and the State Emergency Department Databases (SEDD) for three states (Florida, Massachusetts, and New York), that are made available for the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality. (Healthcare Cost and Utilization Project (HCUP), 2018) The SID includes all inpatient discharge records from community hospitals (including emergency visits that result in hospitalization), and the SEDD includes all emergency department (E.D.) 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. We used data from three states with homeless flags to achieve the broadest range of socioeconomic and geographic diversity in the study. Only 7 states -- 3 states included in our analysis plus Maryland, Georgia, Utah, and Wisconsin -- reported both the homeless indicator and a unique patient linkage number for both SID and SEDD in 2014. The homeless indicator for Utah and Wisconsin's SID/SEDD was severely underreported, the hospital identifier was not available in Georgia's SID/SEDD, and there were very few (<10) homeless pregnant women in Maryland's SID/SEDD; therefore, these states were not included in our analyses). Homeless status was reported directly from the hospitals. (Healthcare Cost and Utilization Project (HCUP), 2008) 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. (Karaca et al., 2013; Manzano-Nunez et al., 2019; Rosendale et al., 2019; R. Sun et al., 2006; B. White et al., 2018; B. M. White et al., 2014) The SEDD was used in combination with the SID to identify homeless individuals, and the main analysis was performed using the SID. Additionally, we used the 2016 American Hospital Association's Annual Survey of Hospitals and the 2014 Medicare Cost Reports to assess hospital characteristics for bivariate analyses.

The study population was restricted to women between the ages of 18-44, who had a hospitalization for delivery in 2014. Although there were only a few women with more than one delivery hospitalization in 2014, the analysis was restricted to the first hospitalization. We excluded women who were missing the homeless indicator (0.6%) or any of the key adjustment variables described below. Childbirth deliveries were identified using the enhanced method for identifying deliveries as described elsewhere,(Kuklina et al., 2008) which uses a combination of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9) diagnosis and procedure codes, and Diagnosis-Related Group (DRG) and are less likely to miss severe obstetric complications compared to a standard method of using V27 codes. See Appendix Table 4.1 for a list of codes.

Outcome variables

Outcome variables were classified into (1) obstetric complications during pregnancy (antepartum hemorrhage, placental abnormalities) or related to labor (premature rupture of membranes, preterm labor, and postpartum hemorrhage), (2) neonatal complications (fetal distress, fetal growth restriction, stillbirth), (3) delivery method (cesarean section), and (4) delivery-related costs. Definitions of childbirth delivery outcomes have been defined in prior studies. (Hayward, Foster, & Tseng, 2017; Zhong et al., 2018) See Appendix Table 4.2 for a list of codes.

Adjustment variables

In our multivariable regression models, we adjusted for patient characteristics and hospital-specific fixed effects. Patient characteristics included age (categorized as 18-24, 25-29, 30-34, 35-39, and 40-44 years old), race and ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, and other), primary insurance type (Medicare, Medicaid, private, self-pay/no charge/other), ever smoking status, multiple births, and 26 comorbidities included in the Elixhauser Comorbidities Index (Healthcare Cost and Utilization Project (HCUP), 2017) (similar medical conditions were combined while excluding ulcer and AIDS due to low cell counts (<3)). Smoking status was identified using ICD-9 codes since these codes have been studied to be reliable indicators for smoking status. (Wiley, Shah, Xu, & Bush, 2013) In the cesarean section outcome model, we additionally adjusted for previous cesarean delivery.

Statistical analysis

To control for sample selection bias, we used a doubly-robust propensity score overlap weighing method. (Fan Li, Morgan, & Zaslavsky, 2018; F. Li, Thomas, & Li, 2019) In both the propensity score and the outcome regression models, we included all of the adjustment variables. Outcome regression models were compared both with and without adjusting for hospital fixed effects (indicator variables for each hospital). Including hospital fixed effects allowed us to compare homeless and non-homeless women treated at the same hospital (Fizmaurice et al., 2011)

Overlap propensity-score weighting method, a form of balancing weights using propensity scores, was selected due to the propensity score distributions exhibiting limited overlap (Fan Li et al., 2018; F. Li et al., 2019; Thomas, Li, & Pencina, 2020) Overlap weights upweights observations with the largest overlap in observed characteristics between the two groups, while downweighing those observations with the least overlap. In other words, it deemphasizes those with propensity scores close to 0 or 1 and emphasizes those close to a propensity score of 0.5. An advantage of using this method over trimming methods is that it does not rely on arbitrarily selecting a cutoff point for the weights and does not involve removing observations. These weights provide estimates of the average treatment effect in the overlap population. (F. Li et al., 2019) Standardized mean differences were used to compare the distribution of patient characteristics before and after applying this weighting method.

Next, we used multivariable linear probability models with standard errors calculated based on a first-order Taylor series approximation 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 (Hellevik, 2009)), adjusting for patient characteristics (age, race/ethnicity, primary payer, ever smoking status, multiple births, 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 each outcome with homeless indicator fixed at each category (0 or 1) and then averaged over the distribution of covariates in our sample. (Williams, 2012)

As our study had multiple outcome variables, we accounted for multiple comparisons using the Benjamini-Hochberg procedure, and setting the false discovery rate threshold to <0.05 ($q<0.05$). (Benjamini & Hochberg, 1995) This method controls the expected proportion of false positives to $<5\%$, and is less conservative compared to family-wise error rate controlling procedures, such as the Bonferonni procedure.

Secondary analyses

We conducted several sensitivity analyses: 1) comparing homeless and non-homeless women using unweighted multivariable regression analysis with hospital fixed effects 2) using a doubly-robust propensity score overlap weighing method to compare homeless and non-homeless women living in zip codes with the lowest quartile of median household income ("low-income housed" women) to control for the effect of poverty, with and without hospital fixed effects, and 3) using a doubly-robust propensity score overlap weighing method to compare homeless and non-homeless women who delivered in non-federal, government-owned hospitals, with and without hospital fixed effects.

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 consisted of 15,029 homeless and 308,242 non-homeless pregnant women who had a delivery hospitalization in 2014 in F.L., M.A., and N.Y. Homeless women, compared to non-homeless women, were younger, much more likely to have Medicaid as the primary payer, more likely to be Non-Hispanic Black, Hispanic or other race/ethnicity (vs White), and more likely to have comorbidities such as hypertension, coagulopathy, obesity, alcohol abuse/liver disease and psychoses. They were less likely to be an ever smoker, have had a previous cesarean section, have multiple births, hypothyroidism, deficiency anemias, and depression (Table 4.1). Homeless women were more likely to be seen in small (1-99 beds)-to-medium (100-300 beds) sized hospitals, hospitals with minor teaching status, government-owned hospitals, and hospitals most likely to be safety-net hospitals (Appendix Table 4.3).

Association between homelessness and delivery outcomes without hospital fixed effects

In the weighted multivariable regression analysis without hospital fixed effects, we found that homeless pregnant women, on average, had a 4.3-percentage-point lower likelihood of receiving a cesarean section (Adjusted probability, 31.8%, 95%CI, 29.3% to 34.3% for homeless vs. 36.1%, 95%CI, 35.9% to 36.4% for non-homeless women; adjusted risk difference [aRD], -4.3%, 95%CI, -6.9% to -1.8%, p=0.01) but a 4.2-percentage-point higher likelihood of having fetal distress (23.4%, 95%CI, 20.7% to 26.2% vs. 19.2%, 95%CI, 19.0% to 19.5%; aRD +4.2%, 95%CI, +1.3% to +7.0%, p=0.02) compared to non-homeless women. While we were not able to reject the null hypothesis, homeless women appeared to also have a higher probability of preterm labor (9.0%, 95%CI, 7.1% to 10.9% vs. 6.7%, 95%CI, 6.6% to 6.9%; aRD +2.2%, 95%CI, +0.2% to +4.2%, p=0.10). (Figures 4.1 and 4.3 and Appendix Table 4.4)

Association between homelessness and delivery outcomes with hospital fixed effects

After adjusting for hospital fixed effects, we found that homeless women had a 3.8 percentage-point higher likelihood of having preterm labor (10.5%, 95%CI, 8.0% to 13.0% vs. 6.7%, 95%CI, 6.5% to 6.9%; aRD, +3.8%, 95%CI, +1.2% to +6.5%; p=0.03) and $550 higher delivery-related costs ($5,970, 95%CI, $5,605 to $6,335 vs. $5,420, 95%CI, $5,393 to $5,448; aRD, +$550, 95%CI, +$168 to +$931; p=0.03). Further, homeless women had a 1.9-percentage-point higher likelihood of having placental abnormalities which trended towards statistical significance (4.0%, 95%CI, 2.4% to 5.5% vs. 2.0%, 95%CI, 1.9% to 2.1%; aRD, +1.9%, 95%CI, +0.4% to +3.5%; p=0.05), However, there were no difference in cesarean section or fetal distress risks between homeless and non-homeless women after adjusting for hospital fixed effects. (Figures 4.2 and 4.3 and Appendix Table 4.4)

Secondary analyses

In the unweighted multivariable regression model controlling for hospital fixed effects and adjusting for false discovery rate, we found similar trends of higher preterm labor and average delivery-related costs for homeless women compared to non-homeless women, but the differences did not reach statistical significance. (Appendix Table 4.5) In the sensitivity analysis among homeless and limited the general population sample to low-income housed women, we did not find the results to change substantially from the main analysis, aside from a loss in power due to the smaller sample. (Appendix Table 4.6) When we restricted the analysis to women who had a delivery in non-federal, government-owned hospitals, we found the same association in the model comparing women across hospitals. In the model that compared women within the same hospital, there were some differences between the two groups that were consistent with the main analysis, but the differences did not reach statistical significance. (Appendix Table 4.7)

DISCUSSION

Using state-wide datasets of all hospital admissions from three large and diverse states, we found homeless pregnant women experienced a higher likelihood of delivery complications for multiple outcomes compared to non-homeless women. These associations, however, varied when comparisons were made across hospitals versus within hospitals. Our findings suggest that homeless pregnant women are facing substantial challenges in receiving quality childbirth-related care, even when they were cared for at the same hospital as non-homeless pregnant women. Our findings also highlight the importance of healthcare providers to screen pregnant women for homelessness and other social needs, and to collaborate with social housing programs to ensure that their healthcare needs, including their social needs, are met.

When we compared homeless versus non-homeless women across hospitals, homeless women had a lower likelihood of receiving a C-section but a higher likelihood of experiencing fetal distress. However, these outcomes did not differ when we compared homeless versus non-homeless women within the same hospital. These findings indicate that for these outcomes, observed differences in rates of C-section and fetal distress could be explained by where pregnant homeless women sought care, i.e. homeless women were disproportionately more likely to seek care at hospitals with lower cesarean section and higher fetal distress rates.

When patients were compared within the same hospital, homeless women had a higher likelihood of experiencing preterm labor, higher delivery-related costs, and a marginally higher probability of having placental abnormalities. These differences may be explained by disparities in the quality of care homeless and non-homeless women receive at the same hospital. Placental abnormalities (previo, abruptio, accreta) can lead to further complications such as heavy bleeding, preterm birth, and stillbirth;(Cleveland Clinic, 2018; Tikkanen, 2011) and preterm labor can result in preterm births. (American College of Obstetricians and Gynecologists & Committee on Practice Bulletins—Obstetrics, 2012) Our findings were consistent with single facility studies that showed that homeless mothers were more likely to experience adverse delivery outcomes such as preterm delivery, low birthweight, and small for gestational age infants than non-homeless mothers. (Little et al., 2005; Paterson & Roderick, 1990) The consequences of such adverse delivery outcomes can have detrimental effects on the mother and the infant over the long term.

Homeless women had higher delivery-related costs compared to non-homeless women when they were compared within hospitals but not when they were compared across hospitals. This difference suggested to us that homeless women received delivery-related care in lower-cost hospitals. To further explore this point, we calculated the proportion of homeless versus non-homeless women by hospital ownership and the average delivery-costs by hospital ownership (See Appendix Table 4.8). The majority of homeless women received care in government-owned, non-federal hospitals, whereas, more than three-quarters of non-homeless women received care in non-government owned, not-for-profit hospitals. Delivery-related costs were, on average lower for government-owned hospitals compared to non-government owned, not-for-profit hospitals ($5,418 vs. $5,621). While a small proportion of all patients were seen in investor-owned, for-profit hospitals and the delivery-related costs were much lower compared to government-owned hospitals and non-government owned non-for-profit hospitals, we found that investor-owned hospitals had much lower rates of delivery complications and a younger and healthier population. This is consistent with other studies that found that for-profit hospitals self-select in better-insured areas, and are more likely to offer profitable services compared to nonprofit and government hospitals (Horwitz, 2005; Norton & Staiger, 1994).

Our results suggest that the majority of homeless pregnant women are being treated in different hospitals from the majority of non-homeless women, but when women were compared within the same hospital, homeless women had worse delivery-related outcomes. Homeless women need to be identified and be connected to resources to help springboard them out of homelessness. The Center for Medicaid and Medicare Services established the Accountable Health Communities model, which provides funding for selected clinic-community collaborations to address social determinants of health through efforts such as screening patients at clinics for social needs. (Centers for Medicare and Medicaid Services, 2017) Yet, evidence indicates that less than a quarter of physicians screen patients for all five social needs: food insecurity, housing instability, unmet needs for utility, transportation needs, and interpersonal violence. (Fraze et al., 2019) Healthcare policies should encourage healthcare providers to screen pregnant women, especially women who are uninsured or covered by Medicaid, for social needs, and collaborate with community resources, such as local housing authorities so that their housing needs are met, and women are able to receive care for their unmet healthcare needs.

To our knowledge, this is one of few studies using multiple states to study childbirth delivery outcomes for homeless compared to non-homeless women. Past studies have found that homeless pregnant women have higher risks for adverse delivery outcomes, such as low birthweight, small for gestational age, and preterm birth (Little et al., 2005; Richards et al., 2011; Stein et al., 2000) however, most previous studies have been limited in sample size and conducted in a single state, region or hospital. (Clark et al., 2019; Little et al., 2005; Paterson & Roderick, 1990; Stein et al., 2000) One population-based study using the Pregnancy Risk Assessment Monitoring System database from 31 states found that infants born to homeless women had worse neonatal outcomes compare to infants born to non-homeless women, but the authors did not assess obstetric delivery complications. Further, while the authors adjusted for the region in their models, they did not control for differences across hospitals. (Richards et al., 2011) In our study, we adjusted for hospital fixed effects, which allowed us to make within hospital comparisons. Additionally, we used a doubly-robust overlap propensity-score weighing method which has the advantage of selecting a clinically relevant target population, achieving covariate balance between the groups, and improving precision compared to other propensity score methods. (Thomas et al., 2020)

Our study has limitations. First, this is a cross-sectional study, and therefore, the temporality between exposure and outcome could not be assessed. However, women were coded as homeless at the time of discharge, so it is unlikely that the delivery complication led to homelessness. Second, as our study was restricted to administrative data, exposure and outcome misclassification is possible. For example, the severity of homelessness is not captured by our data. If temporary homeless women were coded as homeless or if homeless status was underreported, this will only bias our estimates towards the null. Concerns about the over-concentration of homeless individuals in some hospitals were addressed by including hospital fixed effects. Other concerns, such as the distribution of patient characteristics (i.e., a larger proportion of Non-Hispanic Black homeless women) between homeless and non-homeless women was addressed by using overlap propensity score weights. Third, while we adjusted for a broad set of patient demographic and clinical variables in our analyses, we were unable to adjust for several other potential confounders, such as maternal BMI, history of preterm birth and number of prenatal care visits, due to the lack of data. (Kramer, 2003) Overlap weighing method does not account for unmeasured confounders. (Thomas et al., 2020) Lastly, while our study includes all homeless and non-homeless women who had a delivery hospitalization from three states, our findings may not be generalizable to homeless patients in states not included in our analysis or patients who were not hospitalized for deliveries (i.e., home deliveries).

CONCLUSION

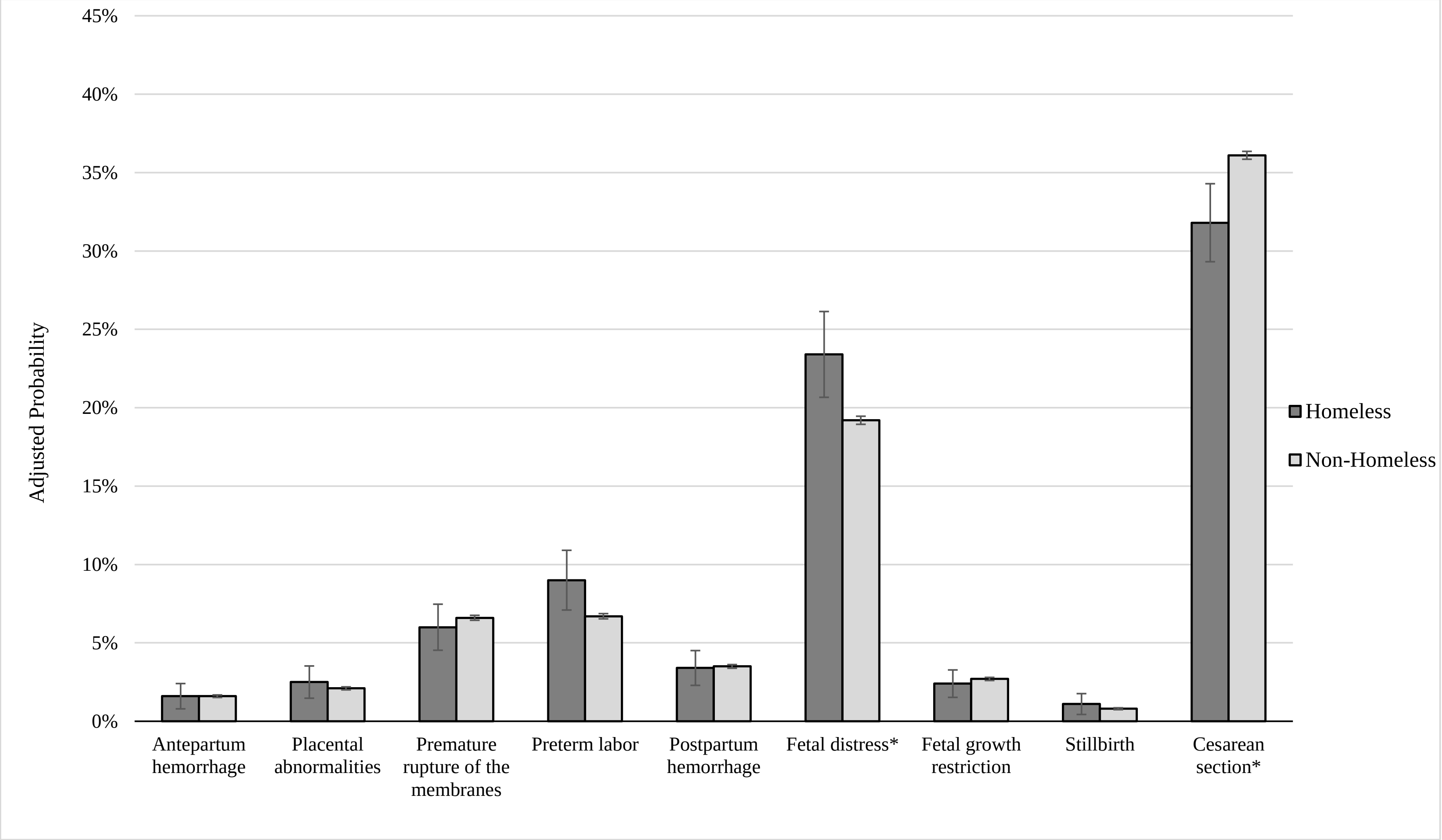
In summary, by analyzing state-wide databases from three large states, we found that homeless pregnant women were more likely to experience childbirth delivery complications and higher costs of delivery compared to non-homeless pregnant women, especially when we compared these two groups of women who were cared for at the same hospital. Our findings highlight the importance of encouraging partnerships between healthcare providers and community resources, such as local social housing programs, to ensure both the social and the healthcare needs of expecting mothers can be appropriately addressed.

Table 4.1. Unweighted and weighted selected characteristics of pregnant women by homeless status

Characteristics	Unweighted %			Weighted % using Overlap Weights		
	Homeless (N=15,029)	Non-Homeless (N=308,242)	Std. Diff.	Homeless (N=15,029)	Non-Homeless (N=308,242)	Std. Diff.
Age Categories						
18-24	28.7%	22.5%	-0.14	29.4%	29.4%	0.00
25-29	28.7%	27.1%	-0.04	29.0%	29.0%	0.00
30-34	24.5%	30.0%	0.12	24.3%	24.3%	0.00
35-39	14.3%	16.4%	0.06	13.8%	13.8%	0.00
40-44	3.7%	4.0%	0.01	3.5%	3.5%	0.00
Payer						
Medicare	0.6%	0.6%	0.01	0.6%	0.6%	0.00
Medicaid	97.8%	47.1%	-1.38	97.5%	97.5%	0.00
Private insurance	1.5%	49.0%	1.31	1.7%	1.7%	0.00
Self-pay/No charge/Other	0.2%	3.3%	0.24	0.2%	0.2%	0.00
Race/ethnicity						
Non-Hispanic White	5.6%	47.3%	1.07	6.2%	6.2%	0.00
Non-Hispanic Black	32.6%	18.7%	-0.32	32.7%	32.7%	0.00
Hispanic	36.6%	18.6%	-0.41	36.2%	36.2%	0.00
Other	25.2%	15.4%	-0.25	24.8%	24.8%	0.00
Ever Smoker	2.5%	5.9%	0.17	2.7%	2.7%	0.00
Multiple Births	1.3%	2.2%	0.06	1.4%	1.4%	0.00
Had a previous Cesarean Section^	17.5%	18.1%	0.02	17.3%	20.7%	-0.09
Selected Elixhauser Co-morbidities						
Hypertension	2.8%	2.3%	-0.03	2.8%	2.8%	0.00
Neurological disorder	0.7%	0.7%	0.00	0.7%	0.7%	0.00
Chronic pulmonary disease	5.0%	4.9%	-0.01	5.1%	5.1%	0.00
Diabetes	1.4%	1.0%	-0.03	1.3%	1.3%	0.00
Hypothyroidism	1.7%	3.6%	0.12	1.7%	1.7%	0.00
Heart, circulation, vascular disease	0.2%	0.4%	0.03	0.2%	0.2%	0.00
Coagulopathy	3.7%	2.7%	-0.05	3.5%	3.5%	0.00
Obesity	9.6%	6.5%	-0.11	9.4%	9.4%	0.00
Fluid and electrolyte disorders	0.6%	0.5%	-0.01	0.6%	0.6%	0.00
Chronic blood loss anemia	13.0%	13.1%	0.00	13.4%	13.4%	0.00
Deficiency Anemias	8.7%	9.7%	0.03	9.1%	9.1%	0.00
Alcohol abuse/ liver disease	0.9%	0.4%	-0.07	0.8%	0.8%	0.00
Drug abuse	1.8%	2.1%	0.02	1.9%	1.9%	0.00
Psychoses	1.6%	0.9%	-0.06	1.6%	1.6%	0.00
Depression	1.5%	2.3%	0.06	1.5%	1.5%	0.00

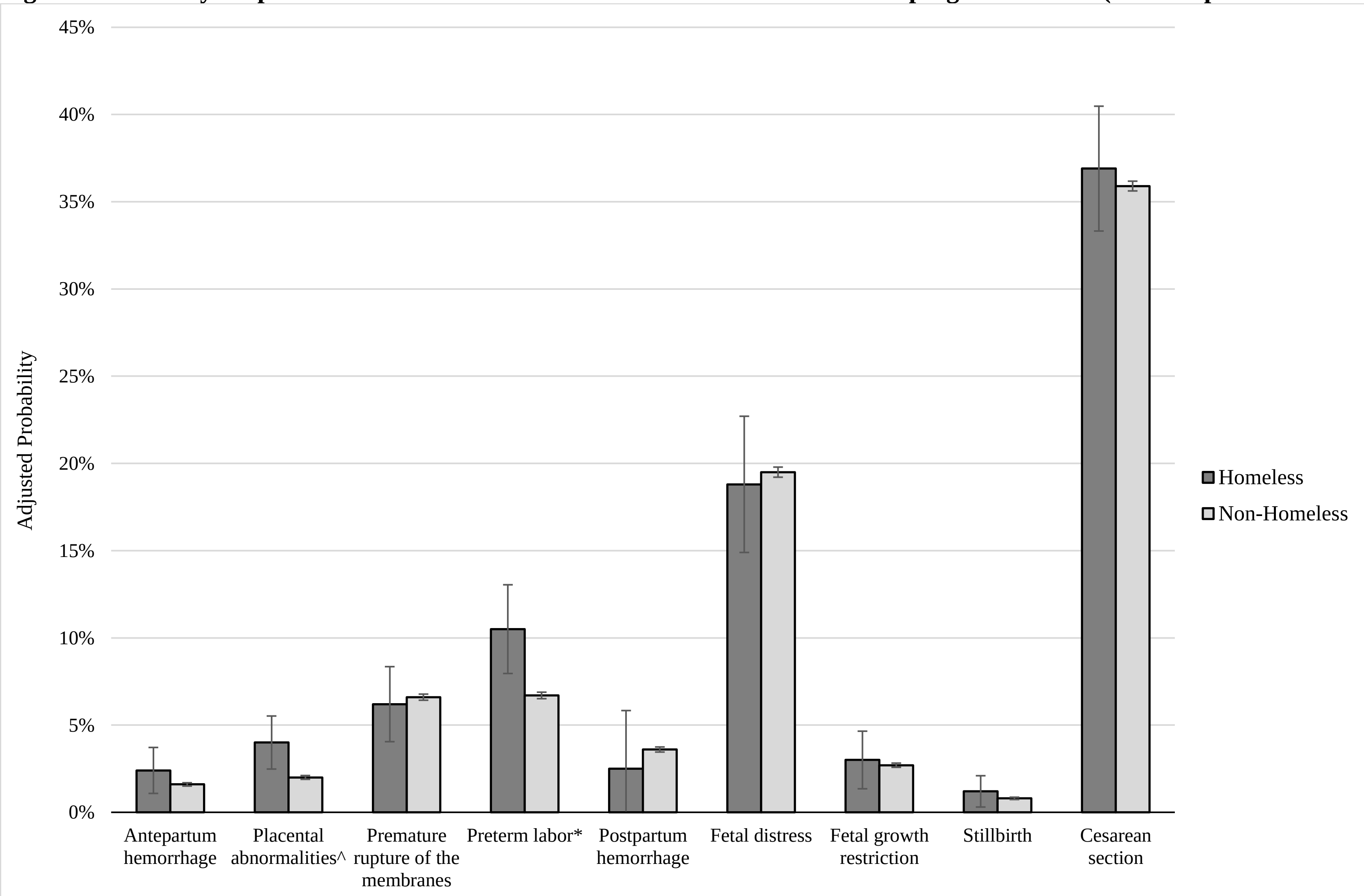
^ Included the final regression model for (cesarean section outcome) but not in the propensity score model
Std. Diff. = Standardized Difference

Figure 4.1. Delivery hospitalization outcomes between homeless and non-homeless pregnant women (without hospital fixed effects)



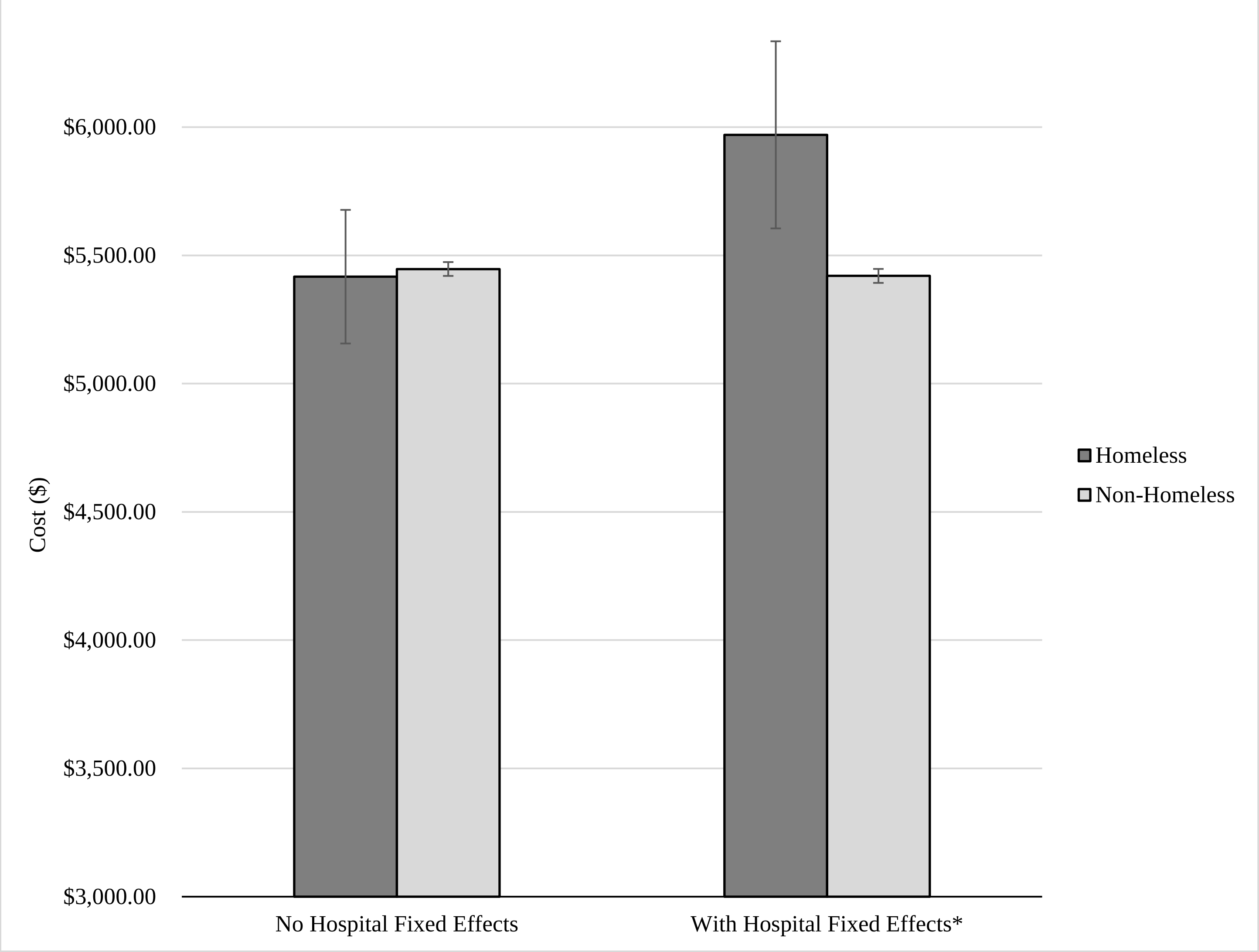
*Adjusted p-value statistically significant at alpha< 0.05

Figure 4.2 Delivery hospitalization outcomes between homeless and non-homeless pregnant women (with hospital fixed effects)



^ Adjusted p-value = 0.05
*Adjusted p-value statistically significant at alpha<0.05

Figure 4.3. Average delivery hospitalization costs between homeless and non-homeless mothers



*Adjusted p-value statistically significant at alpha< 0.05

Appendix

Table 4.1. International Classification of Diseases, Ninth Revision, diagnosis and procedure codes, Diagnosis-Related Group (DRG) codes used to define delivery hospitalizations

Inclusion Criteria	**Codes**
ICD-9 Diagnosis	V27, 650
ICD-9 Procedure	72, 73.22, 73.59, 73.6, 74.0, 74.1, 74.2, 74.4, 74.99
DRG codes	370-375
Exclusion Criteria	**Codes**
ICD-9 Diagnosis	630-639
ICD-9 Procedure	69.01, 69.51, 74.91, 75.0

Table 4.2. International Classification of Diseases, Ninth Revision, diagnosis and procedure codes used to define delivery outcomes

Outcome/Covariate	**ICD-9 Codes**
Covariates (ICD-9 diagnosis)	
Ever smoking	305.1, V15.82, 649.0
Previous cesarean delivery	654.2
Multiple births	V27.2 - V27.7, 651
Obstetric complications during pregnancy (ICD-9 diagnosis)	
Antepartum hemorrhage	641.1, 641.2, 641.3, 641.8, 641.9
Placental abnormalities (previa, abruptio, accreta)	641.0 - 641.2, 667
Obstetric complications before, during and after labor (ICD-9 diagnosis)	
Premature rupture of the membranes	658.10, 658.11, 658.13
Preterm labor	644.0, 644.2
Postpartum hemorrhage	666.0, 666.1, 666.2, 666.3
Neonatal complications (ICD-9 diagnosis)	
Fetal distress	656.3, 656.8, 659.7
Fetal growth restriction	656.5
Stillbirth	656.4, V27.1, V27.3, V27.4, V27.6, V27.7
Delivery method (ICD-9 diagnosis and procedure)	
Cesarean section	
ICD-9 diagnosis	699.7
ICD-9 procedure	74.0, 74.1, 74.2, 74.4, 74.99

Table 4.2. Hospital characteristics by homeless status

Characteristics	Unweighted %		
	Homeless (N=15,029)	Non-Homeless (N=308,242)	Standardized Difference
Large Hospital (400+ beds) vs. Small (1-99)/Medium (100-399)	55.9%	71.1%	0.32
Teaching Status			
Major	2.1%	47.8%	1.24
Minor	97.2%	33.9%	-1.79
Non-Teaching	0.6%	17.4%	0.61
Control Type			
Investor Owned, For-Profit	0.5%	11.9%	0.48
Non-Government, Not for Profit	3.0%	76.4%	2.27
Government	96.4%	10.8%	-3.35
Safety Net Status (≥75th percentile of Disproportionate Share percentage for each state)	98.1%	42.7%	-1.53

Note: These hospital characteristics were not included in the propensity score model or the outcome model.

Table 4.4. Adjusted Delivery Hospitalization Outcomes for Homeless vs. Non-Homeless Women with and without Hospital Fixed Effects

Outcomes	Adjusted Risk No Hospital Fixed Effects: Homeless	Adjusted Risk No Hospital Fixed Effects: Non-Homeless	Adjusted Risk Difference, comparing homeless vs. non-homeless (95% CI)	Unadjusted P-value	Adjusted P-value	Adjusted Risk with Hospital Fixed Effects: Homeless	Adjusted Risk with Hospital Fixed Effects: Non-Homeless	Adjusted Risk Difference, comparing homeless vs. non-homeless (95% CI)	Unadj. P-value	Adj. P-value
Obstetric complications during pregnancy										
Antepartum hemorrhage	1.6% (0.8% to 2.4%)	1.6% (1.6% to 1.7%)	-0.1% (-0.3% to +0.7%)	0.86	0.86	2.4% (1.1% to 3.7%)	1.6% (1.5% to 1.7%)	+0.8% (-0.6% to +2.2%)	0.27	0.52
Placental abnormalities	2.5% (1.5% to 3.5%)	2.1% (2.0% to 2.2%)	+0.4% (-0.7% to +1.5%)	0.46	0.68	4.0% (2.4% to 5.5%)	2.0% (1.9% to 2.1%)	+1.9% (+0.4% to +3.5%)	0.02	0.05^
Obstetric complications before, during and after labor										
Premature rupture of the membranes	6.0% (4.5% to 7.5%)	6.6% (6.4% to 6.7%)	-0.6% (-2.1% to +0.9%)	0.46	0.68	6.2% (4.1% to 8.4%)	6.6% (6.4% to 6.7%)	-0.4% (-2.6% to +1.9%)	0.76	0.76
Preterm labor	9.0% (7.1% to 10.9%)	6.7% (6.6% to 6.9%)	+2.2% (0.2% to +4.2%)	0.03	0.10	10.5% (8.0% to 13.0%)	6.7% (6.5% to 6.9%)	+3.8% (+1.2% to +6.5%)	0.01	0.03*
Postpartum hemorrhage	3.4% (2.3% to 4.5%)	3.5% (3.4% to 3.7%)	-0.1% (-1.3% to +1.0%)	0.86	0.86	2.5% (0.4% to 4.5%)	3.6% (3.4% to 3.7%)	-1.1% (-3.2% to +1.0%)	0.31	0.52
Neonatal complications										
Fetal distress	23.4% (20.7% to 26.2%)	19.2% (19.0% to 19.5%)	+4.2% (+1.3% to +7.0%)	0.004	0.02*	18.8% (14.9% to 22.8%)	19.5% (19.2% to 19.8%)	-0.6% (-4.7% to +3.5%)	0.76	0.76
Fetal growth restriction	2.4% (1.5% to 3.2%)	2.7% (2.6% to 2.8%)	-0.3% (-1.2% to +0.6%)	0.47	0.68	3.0% (1.4% to 4.7%)	2.7% (2.5% to 2.8%)	+0.4% (-1.4% to +2.1%)	0.67	0.76
Stillbirth	1.1% (0.4% to 1.7%)	0.8% (0.7% to 0.8%)	+0.3% (-0.4% to +1.0%)	0.38	0.68	1.2% (0.3% to 2.1%)	0.8% (0.7% to 0.8%)	+0.5% (-0.5% to 1.4%)	0.31	0.52
Delivery method										
Cesarean section	31.8% (29.3% to 34.3%)	36.1% (35.9% to 36.4%)	-4.3% (-6.9% to -1.8%)	0.001	0.01*	36.9% (33.3% to 40.5%)	35.9% (35.6% to 36.1%)	+1.1% (-2.7% to +4.8%)	0.58	0.76
Health services outcome										
Cost	$5,417 ($5,156 to $5,677)	$5,447 ($5,420 to $5,474)	-$30 (-$302 to +$241)	0.83	0.86	$5,970 ($5,605 to $6,335)	$5,420 ($5,393 to $5,448)	+$550 (+$168 to +$931)	0.01	0.03*

*Statistically significant after adjusting for multiple hypothesis testing, using Benjamini-Hochberg false discovery rate threshold q=0.05

^ Adjusted p=0.05

Table 4.5. Unweighted Adjusted Delivery Outcomes for Homeless vs. Non-Homeless Women with Hospital Fixed Effects

Outcomes	Unweighted Adjusted Risk with Hospital Fixed Effects: Homeless	Unweighted Adjusted Risk with Hospital Fixed Effects: Non-Homeless	Unweighted Adjusted Risk Difference, comparing homeless vs. non-homeless (95% CI)	Unadjusted P-value	Adjusted P-value
Obstetric complications during pregnancy					
Antepartum hemorrhage	2.0% (1.0% to 2.9%)	1.6% (1.6% to 1.7%)	+0.4% (-0.6% to +1.3%)	0.48	0.55
Placental abnormalities	3.0% (1.9% to 4.1%)	2.1% (2.1% to 2.2%)	+0.9% (-0.3% to +2.0%)	0.14	0.35
Obstetric complications during and after labor					
Premature rupture of the membranes	7.2% (5.4% to 9.0%)	6.5% (6.4% to 6.6%)	+0.7% (-1.2% to +2.6%)	0.47	0.55
Preterm labor	8.0% (6.3% to 9.8%)	6.0% (5.9% to 6.1%)	+2.0% (+0.2% to +3.8%)	0.03	0.15
Postpartum hemorrhage	1.9% (0.6% to 3.2%)	3.4% (3.3% to 3.5%)	-1.5% (-2.9% to -0.2%)	0.03	0.15
Neonatal complications					
Fetal distress	19.6% (16.7% to 22.4%)	18.8% (18.6% to 19.0%)	+0.7% (-2.2% to +3.7%)	0.63	0.63
Fetal growth restriction	3.2% (2.0% to 4.4%)	2.7% (2.6% to 2.8%)	+0.5% (-0.7% to +1.8%)	0.42	0.55
Stillbirth	0.9% (0.3% to 1.5%)	0.6% (0.6% to 0.7%)	+0.3% (-0.3% to +0.9%)	0.35	0.55
Delivery method					
Cesarean section	36.2% (33.2% to 39.1%)	35.1% (34.9% to 35.3%)	+1.1% (-2.0% to +4.1%)	0.50	0.55
Health services outcome					
Cost	$5,612 ($5,302 to $5,923)	$5,342 ($5,321 to $5,363)	+$270 (-$55.0 to +$595)	0.10	0.34

Note: none of the outcomes are statistically significant after adjusting for multiple hypothesis testing

Table 4.6. Adjusted Delivery Hospitalization Outcomes for Homeless vs. Low-Income Housed Women with and without Hospital Fixed Effects

	Adjusted Risk No Hospital Fixed Effects					Adjusted Risk with Hospital Fixed Effects				
Outcomes	Homeless (15,029)	Non-Homeless (94,739)	Adjusted Risk Difference, comparing homeless vs. non-homeless (95% CI)	Unadjusted P-value	Adjusted P-value	Homeless (15,029)	Non-Homeless (94,739)	Adjusted Risk Difference, comparing homeless vs. non-homeless (95% CI)	Unadj. P-value	Adj. P-value
Obstetric complications during pregnancy										
Antepartum hemorrhage	1.6% (1.1% to 2.0%)	1.7% (1.6% to 1.8%)	-0.1% (-0.6% to 0.3%)	0.59	0.78	2.9% (1.6% to 4.2%)	1.5% (1.3% to 1.7%)	+1.4% (-0.1% to 2.9%)	0.07	0.13
Placental abnormalities	2.3% (1.8% to 2.9%)	2.1% (2.0% to 2.2%)	+0.2% (-0.4% to 0.8%)	0.44	0.78	3.9% (2.3% to 5.4%)	1.9% (1.6% to 2.1%)	+2.0% (0.2% to 3.8%)	0.03	0.09
Obstetric complications before, during and after labor										
Premature rupture of the membranes	6.3% (5.5% to 7.1%)	6.5% (6.3% to 6.8%)	-0.2% (-1.1% to 0.6%)	0.62	0.78	6.3% (4.5% to 8.1%)	6.5% (6.2% to 6.9%)	-0.2% (-2.3% to 1.8%)	0.83	0.85
Preterm labor	7.7% (6.7% to 8.7%)	7.0% (6.7% to 7.2%)	+0.7% (-0.4% to 1.8%)	0.21	0.52	9.7% (7.5% to 11.9%)	6.7% (6.3% to 7.1%)	+3.0% (0.5% to 5.6%)	0.02	0.09
Postpartum hemorrhage	4.0% (3.5% to 4.6%)	3.6% (3.4% to 3.8%)	+0.5% (-0.2% to 1.1%)	0.18	0.52	3.8% (2.2% to 5.4%)	3.6% (3.3% to 3.9%)	+0.2% (-1.6% to 2.1%)	0.82	0.85
Neonatal complications										
Fetal distress	23.6% (22.8% to 25.0%)	20.0% (19.6% to 20.4%)	+3.6% (2.0% to 5.2%)	<0.01	<0.01*	19.9% (16.8% to 23.0%)	20.6% (20.0% to 21.2%)	-0.7% (-4.2% to 2.9%)	0.71	0.85
Fetal growth restriction	2.5% (2.1% to 3.0%)	2.6% (2.5% to 2.7%)	-0.1% (-0.6% to 0.5%)	0.84	0.84	3.7% (2.3% to 5.1%)	2.4% (2.2% to 2.7%)	+1.3% (-0.3% to 2.9%)	0.12	0.21
Stillbirth	0.9% (0.6% to 1.3%)	0.8% (0.7% to 0.9%)	+0.1% (-0.3% to 0.5%)	0.50	0.78	0.9% (0.0% to 1.8%)	0.8% (0.7% to 1.0%)	+0.1% (-0.9% to 1.1%)	0.85	0.85
Delivery method										
Cesarean section	32.0% (30.7% to 33.2%)	35.9% (35.6% to 36.3%)	-4.0% (-5.4% to -2.5%)	<0.01	<0.01*	38.2% (35.3% to 41.1%)	34.9% (34.4% to 35.5%)	+3.3% (-0.1% to 6.7%)	0.06	0.13
Health services outcome										
Cost	$5,339 ($5,199 to $5,479)	$5,322 ($5,283 to $5,361)	$17 (-$141 to $175)	0.83	0.84	$5,987 ($5,629 to $6,344)	$5,219 ($5,157 to $5,281)	$768 ($357 to $1,179)	<0.01	<0.01*

Adjusted for patient characteristics (age, race/ethnicity, payer, ever smoker, multiple births, Elixhauser co-morbidities)

*Statistically significant after adjusting for multiple hypothesis testing, using Benjamini-Hochberg false discovery rate threshold q=0.05

Table 4.7. Adjusted Delivery Hospitalization Outcomes for Homeless vs. Non-Homeless Women in Government Owned Non-Federal Hospitals, with and without Hospital Fixed Effects

Outcomes	Adjusted Risk No Hospital Fixed Effects: Homeless (N=14,495)	Adjusted Risk No Hospital Fixed Effects: Non-Homeless (35,940)	Adjusted Risk Difference, comparing homeless vs. non-homeless (95% CI)	Unadjusted P-value	Adjusted P-value	Adjusted Risk with Hospital Fixed Effects: Homeless (N=14,495)	Adjusted Risk with Hospital Fixed Effects: Non-Homeless (35,940)	Adjusted Risk Difference, comparing homeless vs. non-homeless (95% CI)	Unadj. P-value	Adj. P-value
Obstetric complications during pregnancy										
Antepartum hemorrhage	1.3% (0.8% to 1.7%)	1.8% (1.6% to 2.0%)	-0.5% (-1.0% to 0.1%)	0.09	0.30	1.6% (-0.3% to 3.6%)	1.7% (1.1% to 2.3%)	-0.1% (-2.6% to 2.5%)	0.96	0.96
Placental abnormalities	2.0% (1.3% to 2.8%)	2.2% (1.9% to 2.5%)	-0.2% (-1.1% to 0.8%)	0.71	0.89	2.9% (1.3% to 4.4%)	2.0% (1.5% to 2.4%)	+0.9% (-1.1% to 2.9%)	0.37	0.75
Obstetric complications before, during and after labor										
Premature rupture of the membranes	5.4% (4.4% to 6.3%)	4.8% (4.4% to 5.2%)	+0.6% (-0.6% to 1.8%)	0.36	0.60	3.1% (-0.2% to 6.3%)	5.5% (4.4% to 6.5%)	-2.4% (-6.6% to 1.9%)	0.27	0.75
Preterm labor	8.1% (6.6% to 9.6%)	6.9% (6.4% to 7.4%)	+1.2% (-0.8% to 3.1%)	0.24	0.48	7.3% (4.2% to 10.5%)	7.2% (6.2% to 8.3%)	+0.1% (-4.0% to 4.3%)	0.96	0.96
Postpartum hemorrhage	3.7% (2.8% to 4.6%)	3.7% (3.4% to 4.0%)	0.0% (-1.2% to 1.1%)	0.96	0.96	2.1% (-0.9% to 5.1%)	4.2% (3.2% to 5.1%)	-2.1% (-5.9% to 1.8%)	0.30	0.75
Neonatal complications										
Fetal distress	24.2% (22.1% to 26.4%)	15.9% (15.2% to 16.6%)	+8.3% (5.6% to 11.1%)	<0.01	<0.01*	14.7% (9.3% to 20.0%)	18.8% (17.1% to 20.5%)	-4.2% (-11.1% to 2.8%)	0.24	0.75
Fetal growth restriction	2.2% (1.6% to 2.8%)	2.8% (2.5% to 3.0%)	-0.6% (-1.3% to 0.2%)	0.12	0.31	2.6% (0.7% to 4.5%)	2.7% (2.1% to 3.3%)	-0.1% (-2.5% to 2.4%)	0.95	0.96
Stillbirth	1.0% (0.4% to 1.7%)	0.7% (0.5% to 0.9%)	+0.3% (-0.5% to 1.1%)	0.46	0.66	1.2% (0.3% to 2.0%)	0.7% (0.4% to 1.0%)	+0.5% (-0.6% to 1.6%)	0.41	0.75
Delivery method										
Cesarean section	30.9% (28.8% to 32.9%)	37.4% (36.6% to 38.1%)	-6.5% (-9.0% to -4.0%)	<0.01	<0.01*	37.5% (32.4% to 42.6%)	35.4% (33.8% to 37.0%)	2.2% (-4.4% to 8.7%)	0.52	0.75
Health services outcome										
Cost	$5,654 ($5,365 to $5,943)	$5,678 ($5,570 to $5,787)	-$25 ($-392 to $343)	0.90	0.96	$5,843 ($5,389 to $6,300)	$5,620 ($5,475 to $5,766)	$223 ($-362 to $807)	0.46	0.75

*Statistically significant after adjusting for multiple hypothesis testing, using Benjamini-Hochberg false discovery rate threshold q=0.05

Table 4.8. Proportion of homeless vs. non-homeless women by hospital control type and average delivery-related costs by hospital control type

	Homeless (N=15,029)	Non-Homeless (N=308,242)	Average delivery-related costs
Control Type			
Investor Owned, For-Profit	0.5%	11.9%	$3,567
Non-Government, Not for Profit	3.0%	76.4%	$5,621
Government, Non-Federal	96.4%	10.8%	$5,418

CHAPTER V. CONCLUSIONS

This dissertation explored adverse health services outcomes for homeless patients using the state-wide hospital and ED discharge data from Florida, Maryland (MD excluded from Chapter IV), Massachusetts and New York in 2014.

Chapter II explored opioid and opioid-related hospitalization/ED visit risks between homeless and low-income housed patients. Homeless patients had higher risks of experiencing an opioid overdose (a +1.5 percentage-point difference) and an opioid-related hospitalization(s)/ED visit(s) (a +8.9 percentage-point difference) compared to low-income housed patients. Over 1 in 10 homeless patients had an opioid-related hospitalization/ED visit in 2014. In the sex and race/ethnicity stratified analyses, non-Hispanic white females had the highest risks for both outcomes among the homeless population.

The study in Chapter III compared opioid overdose, opioid-related visits, in-hospital mortality, mechanical ventilation risks and the number of hospitalizations among homeless patients with four or more, two to three and one ED visit(s). Homeless patients with 4 or more ED visits in a year had much higher risks for opioid overdose, opioid-related hospitalizations/ED visits, mechanical ventilation, and a greater number of hospitalizations compared to homeless patients with 2-3 ED visits or 1 ED visit. Patients with 4 or more and 2-3 ED visits had similar in-hospital mortality risks that were higher than patients with 1 ED visit.

Finally, the study in Chapter IV explored obstetric and fetal outcomes, and costs between homeless and non-homeless pregnant women who had a delivery hospitalization in 2014. Several pregnancy delivery complications outcomes were worse for homeless pregnant women in comparison to non-homeless women, but the outcomes differed whether the comparison was made across hospitals versus within hospitals. When homeless women were compared to non-homeless women across hospitals, they had a higher likelihood of experiencing fetal distress, but a lower likelihood of having a c-section. When women were compared within the same hospital, homeless women had higher hospitalization costs and higher likelihood of having placental abnormalities and preterm labor. Secondary analyses found that homeless women presented to predominantly government-owned safety-net hospitals where the average delivery costs are lower.

All three studies have important healthcare practice, policy, and future research implications.

Policy Implications/Recommendations

Identifying the Homeless and Targeted Interventions

The combined results of the three studies suggest that 1) social screenings are needed to identify homeless patients at the hospitals and 2) a one-size-fits-all approach for intervening on the homeless is not recommended. Homeless patients each have their unique background and circumstances that led them to become homeless, and the degree and duration of homelessness can also differ for each person. Interventions for homeless patients must be carefully designed so that patients at the highest risk are identified and appropriate treatment which takes into consideration his/her circumstances should be delivered.

The findings from Chapters II and IV provide evidence that homeless patients who seek care in hospitals and ED's are a high-risk group that experience serious health services utilization outcomes at a higher rate than the non-homeless comparison group. The findings from the frequent ED utilizer study in Chapter III indicate that even among homeless patients who seek care in ED's, patients who return to the ED multiple times have worse outcomes and differential risk factors than those who have just one ED visit in a given year. Homeless patients are oftentimes classified as one category, but the higher-risk patients with 4 or more ED visits are more likely to qualify for Medicare under the age of 65 (a proxy for disability status), and have multiple co-morbidities, such as alcohol abuse, psychoses, or chronic pulmonary disease.

Clinical Practice and Policy Implications

For hospitals and clinics, implementing systematic screenings for social needs, particularly housing, may be the first step in alleviating the healthcare needs of homeless patients and reducing their societal burden. It is encouraging that the Center for Medicare and Medicaid Services (CMS) has recently established the Accountable Health Communities model, which aims to address social determinants of health through a community partnership approach (Centers for Medicare and Medicaid Services, 2017). CMS is offering waivers for clinic-community partnerships, such as incorporating screenings for social needs and referring patients to community partners. While screenings are critical, one study found that only a small fraction of physicians screen their patients for all five social needs (Fraze et al., 2019).

Therefore, at the policy level, clinicians should be encouraged to screen their patients, and at the hospital-level, built-in processes that relieve rather than add to the clinician's workload may be necessary. Incentives for providers may include billing for a specific health screening procedure code, or linking screening to performance bonuses. An example to reduce the burden on the clinician is to use a clinical decision support tool that quickly identifies possible homeless patients using advanced analytics algorithms. The same clinical support tool can then link the patient to community partners and resources tailored to that individual. Hospitals and clinics can reference the "Obesity Toolkit" on the Agency for Healthcare Research and Quality website (Agency for Healthcare Research and Quality, 2014), for recommendations and examples of pilot projects that used a clinical decision support platform for linking primary care patients to community resources for obesity management.

Since many hospitals are constrained in resources, screenings may be targeted to patients meeting specific criteria, which can be built into the clinical decision support tool. Such criteria may include: patients who present themselves to the ED more than once within a year, who are either uninsured, have Medicaid coverage, or have Medicare coverage under the age of 65, and have alcohol abuse, drug abuse or mental illness as a co-morbidity. For women who present themselves to their first prenatal care visit, the selection criterion may be less stringent and may be extended to all women who are uninsured, covered by Medicaid or Medicare under the age of 65.

Addressing opioid abuse and overdose

Once homeless patients are identified, clinicians should further screen homeless patients for opioids related disorders, and refer them to appropriate care, as well as prescribe naloxone if necessary. Since non-Hispanic White homeless females had the highest risk for both opioid overdose and opioid-related visits, clinicians should be aware of this high-risk group and have gender and culturally appropriate resources available (i.e., not referring women to treatment centers that mostly treat men and screen women for domestic violence).

Addressing pregnancy delivery complications

Identifying housing insecurity and homelessness is particularly crucial for pregnant women. Circumstances associated with homelessness, like malnutrition, unsanitary conditions, underlying chronic health conditions can affect the health of the mother and the fetus during pregnancy. Housing interventions should also be prioritized for pregnant homeless women, and hospitals should have partnerships with social housing programs. Ideally, screenings should be incorporated as part of someone's first prenatal care appointment. She can then be referred to the appropriate community resource, receive housing and other social support and any underlying health conditions can be managed during her pregnancy.

Limitations

There are limitations to all three studies. First, all three studies were analyzed cross-sectionally, therefore, the temporality between exposure and outcome cannot be assessed. While unlikely, it is plausible that the outcome (i.e., opioid overdose) had an impact on one's finances and/or physical and mental health, which led him/her to become homeless (or have multiple ED visits).

Next, misclassification of the exposure and outcome is a limitation that is inherent in administrative databases. Homelessness is a dynamic status and the severity of homelessness could not be captured by the data. The reliability of the homeless indicator may also be a concern, particularly for Florida and Maryland because of the lower homeless counts. This indicator, however, has been used by multiple different researchers in the past (Karaca et al., 2013; Manzano-Nunez et al., 2019; Rosendale et al., 2019; R. Sun et al., 2006; Wadhera, Choi, et al., 2019; B. White et al., 2018; B. M. White et al., 2014). Hospitals also have financial incentives associated with billing and collection to accurately determine where the patient lives. Additionally, a sensitivity analysis restricted to NY for the first opioid study indicated that the results did not change substantially. Most outcomes were identified using ICD-9 codes defined in previous studies. Some hospitals may systematically under or over-code a particular diagnosis, however, this problem was minimized by controlling for hospital fixed effects in all three studies.

Lastly, both generalizability to the general homeless population and to other states not included in these analyses is limited. All three studies focused on homeless adults who sought care at the hospital or ED, therefore, the findings are not generalizable to healthier or sicker homeless people (i.e. died from opioid overdose) who did not have a hospitalization/ED visit. Further, as these studies used data from four states (three for the delivery hospitalization study), the results are not generalizable to other states that were not included in the study.

Regardless of the aforementioned limitations, the three studies are some of the largest studies, using multiple states, to study the health services use and outcomes of the homeless population in the inpatient and ED settings. Selecting comparable comparison groups minimized selection bias and adjusting for hospital fixed effects allowed for within-hospital comparisons. I hope that these studies will be informative for hospitals, policymakers, community organizations and researchers for improving the health and social needs of the homeless population.

REFERENCES

Agency for Healthcare Research and Quality. (2014). Community Connections: Linking Primary Care Patients to Local Resources for Better Management of Obesity. Retrieved from https://www.ahrq.gov/ncepcr/tools/obesity-kit/index.html

Aidala, A. A., Wilson, M. G., Shubert, V., Gogolishvili, D., Globerman, J., Rueda, S., . . . Rourke, S. B. (2016). Housing Status, Medical Care, and Health Outcomes Among People Living With HIV/AIDS: A Systematic Review. *Am J Public Health, 106*(1), e1-e23. doi:10.2105/ajph.2015.302905

American College of Obstetricians and Gynecologists, & Committee on Practice Bulletins—Obstetrics. (2012). ACOG practice bulletin no. 127: Management of preterm labor. *Obstet Gynecol, 119*(6), 1308-1317. doi:10.1097/AOG.0b013e31825af2f0

Andersen, R. M. (1968). *Families' use of health services: a behavioral model of predisposing, enabling and need components.* (PhD dissertation), Purdue University, West Lafayette, In. Retrieved from http://docs.lib.purdue.edu/dissertations/AAI6902884/

Anderson, K. O., Green, C. R., & Payne, R. (2009). Racial and ethnic disparities in pain: causes and consequences of unequal care. *J Pain, 10*(12), 1187-1204. doi:10.1016/j.jpain.2009.10.002

Aubry, T., Nelson, G., & Tsemberis, S. (2015). Housing First for People With Severe Mental Illness Who Are Homeless: A Review of the Research and Findings From the At Home-Chez soi Demonstration Project. *Can J Psychiatry, 60*(11), 467-474. doi:10.1177/070674371506001102

Baggett, T. P., Hwang, S. W., O'Connell, J. J., Porneala, B. C., Stringfellow, E. J., Orav, E. J., . . . Rigotti, N. A. (2013). Mortality among homeless adults in Boston: shifts in causes of death over a 15-year period. *JAMA Intern Med, 173*(3), 189-195. doi:10.1001/jamainternmed.2013.1604

Baggett, T. P., Singer, D. E., Rao, S. R., O'Connell, J. J., Bharel, M., & Rigotti, N. A. (2011). Food insufficiency and health services utilization in a national sample of homeless adults. *J Gen Intern Med, 26*(6), 627-634. doi:10.1007/s11606-011-1638-4

Bamrah, S., Yelk Woodruff, R. S., Powell, K., Ghosh, S., Kammerer, J. S., & Haddad, M. B. (2013). Tuberculosis among the homeless, United States, 1994-2010. *Int J Tuberc Lung Dis, 17*(11), 1414-1419. doi:10.5588/ijtld.13.0270

Basu, A., Kee, R., Buchanan, D., & Sadowski, L. S. (2012). Comparative cost analysis of housing and case management program for chronically ill homeless adults compared to usual care. *Health Serv Res, 47*(1 Pt 2), 523-543. doi:10.1111/j.1475-6773.2011.01350.x

Beal, A. C., & Redlener, I. (1995). Enhancing perinatal outcome in homeless women: the challenge of providing comprehensive health care. *Semin Perinatol, 19*(4), 307-313. doi:10.1016/s0146-0005(05)80046-1

Becker, W. C., Sullivan, L. E., Tetrault, J. M., Desai, R. A., & Fiellin, D. A. (2008). Non-medical use, abuse and dependence on prescription opioids among U.S. adults: psychiatric, medical and substance use correlates. *Drug Alcohol Depend, 94*(1-3), 38-47. doi:10.1016/j.drugalcdep.2007.09.018

Beijer, U., Wolf, A., & Fazel, S. (2012). Prevalence of tuberculosis, hepatitis C virus, and HIV in homeless people: a systematic review and meta-analysis. *Lancet Infect Dis, 12*(11), 859-870. doi:10.1016/s1473-3099(12)70177-9

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society, Series B (Methodology)*(57), 289-300.

Berkowitz, S. A., Kalkhoran, S., Edwards, S. T., Essien, U. R., & Baggett, T. P. (2018). Unstable Housing and Diabetes-Related Emergency Department Visits and Hospitalization: A Nationally Representative Study of Safety-Net Clinic Patients. *Diabetes Care, 41*(5), 933-939. doi:10.2337/dc17-1812

Bharel, M., Lin, W. C., Zhang, J., O'Connell, E., Taube, R., & Clark, R. E. (2013). Health care utilization patterns of homeless individuals in Boston: preparing for Medicaid expansion under the Affordable Care Act. *Am J Public Health, 103 Suppl 2*, S311-317. doi:10.2105/ajph.2013.301421

Bloom, K. C., Bednarzyk, M. S., Devitt, D. L., Renault, R. A., Teaman, V., & Van Loock, D. M. (2004). Barriers to prenatal care for homeless pregnant women. *J Obstet Gynecol Neonatal Nurs, 33*(4), 428-435. doi:10.1177/0884217504266775

Bohnert, A. S., Valenstein, M., Bair, M. J., Ganoczy, D., McCarthy, J. F., Ilgen, M. A., & Blow, F. C. (2011). Association between opioid prescribing patterns and opioid overdose-related deaths. *Jama, 305*(13), 1315-1321. doi:10.1001/jama.2011.370

Burt, M. R., Aron, L. Y., Douglas, T., Valente, J., Lee, E., & Iwen, B. (1999). *Homelessness: Programs and the People They Serve | Findings of the National Survey of Homeless Assistance Providers and Clients*. Retrieved from https://www.urban.org/research/publication/homelessness-programs-and-people-they-serve-findings-national-survey-homeless-assistance-providers-and-clients

Buzza, C., Elser, A., & Seal, J. (2019). A Mobile Buprenorphine Treatment Program for Homeless Patients With Opioid Use Disorder. *Psychiatr Serv, 70*(7), 635-636. doi:10.1176/appi.ps.70701

Centers for Disease Control and Prevention. (2018). HIV/AIDS Basic Statistics. Retrieved from https://www.cdc.gov/hiv/basics/statistics.html

Centers for Medicare and Medicaid Services. (2017, 3/6/2020). Accountable Health Communities Model. Retrieved from https://innovation.cms.gov/initiatives/ahcm/

Cepeda, M. S., Fife, D., Chow, W., Mastrogiovanni, G., & Henderson, S. C. (2012). Assessing opioid shopping behaviour: a large cohort study from a medication dispensing database in the US. *Drug Saf, 35*(4), 325-334. doi:10.2165/11596600-000000000-00000

Chatterjee, A., Yu, E. J., & Tishberg, L. (2018). Exploring opioid use disorder, its impact, and treatment among individuals experiencing homelessness as part of a family. *Drug Alcohol Depend, 188*, 161-168. doi:10.1016/j.drugalcdep.2018.04.012

Cintron, A., & Morrison, R. S. (2006). Pain and ethnicity in the United States: A systematic review. *J Palliat Med, 9*(6), 1454-1473. doi:10.1089/jpm.2006.9.1454

City of Los Angeles. Confronting the Crisis: Homelessness. Retrieved from https://www.lamayor.org/Homelessness

Clark, R. E., Weinreb, L., Flahive, J. M., & Seifert, R. W. (2019). Homelessness Contributes To Pregnancy Complications. *Health Aff (Millwood), 38*(1), 139-146. doi:10.1377/hlthaff.2018.05156

Cleveland Clinic. (2018). Placental Accreta. Retrieved from https://my.clevelandclinic.org/health/diseases/17846-placenta-accreta

Cochran, G., Gordon, A. J., Lo-Ciganic, W. H., Gellad, W. F., Frazier, W., Lobo, C., . . . Donohue, J. M. (2017). An Examination of Claims-based Predictors of Overdose from a Large Medicaid Program. *Med Care, 55*(3), 291-298. doi:10.1097/mlr.0000000000000676

Council of Economic Advisors. (2017). *The Underestimated Cost of the Opioid Crisis*. Retrieved from https://www.whitehouse.gov/sites/whitehouse.gov/files/images/The%20Underestimated%20Cost%20of%20the%20Opioid%20Crisis.pdf.

Culhane, D. P., Metraux, S., & Bainbridge, J. (2010). *The Age Structure of Contemporary Homelessness: Risk Period or Cohort Effect?* Penn School of Social Policy and Practice Working Paper.

Didenko, E., & Pankratz, N. (2007). Substance Use: Pathways to homelessness? Or a way of adapting to street life? *Visions Journal, 4*(1), 9-10.

DiPietro, B. Y., Kindermann, D., & Schenkel, S. M. (2012). Ill, itinerant, and insured: the top 20 users of emergency departments in Baltimore city. *ScientificWorldJournal, 2012*, 726568. doi:10.1100/2012/726568

Doran, K. M., Rahai, N., McCormack, R. P., Milian, J., Shelley, D., Rotrosen, J., & Gelberg, L. (2018). Substance use and homelessness among emergency department patients. *Drug Alcohol Depend, 188*, 328-333. doi:10.1016/j.drugalcdep.2018.04.021

Doran, K. M., Raven, M. C., & Rosenheck, R. A. (2013). What drives frequent emergency department use in an integrated health system? National data from the Veterans Health Administration. *Ann Emerg Med, 62*(2), 151-159. doi:10.1016/j.annemergmed.2013.02.016

Dowell, D., Haegerich, T. M., & Chou, R. (2016). CDC Guideline for Prescribing Opioids for Chronic Pain - United States, 2016. *MMWR Recomm Rep, 65*(1), 1-49. doi:10.15585/mmwr.rr6501e1

Dunn, K. M., Saunders, K. W., Rutter, C. M., Banta-Green, C. J., Merrill, J. O., Sullivan, M. D., . . . Von Korff, M. (2010). Opioid prescriptions for chronic pain and overdose: a cohort study. *Ann Intern Med, 152*(2), 85-92. doi:10.7326/0003-4819-152-2-201001190-00006

Dyer, O. (2018). US life expectancy falls for third year in a row. *Bmj, 363*, k5118. doi:10.1136/bmj.k5118

Embleton, L., Lee, H., Gunn, J., Ayuku, D., & Braitstein, P. (2016). Causes of Child and Youth Homelessness in Developed and Developing Countries: A Systematic Review and Meta-analysis. *JAMA Pediatr, 170*(5), 435-444. doi:10.1001/jamapediatrics.2016.0156

Fazel, S., Geddes, J. R., & Kushel, M. (2014). The health of homeless people in high-income countries: descriptive epidemiology, health consequences, and clinical and policy recommendations. *Lancet, 384*(9953), 1529-1540. doi:10.1016/s0140-6736(14)61132-6

Fischer, P. J., Shapiro, S., Breakey, W. R., Anthony, J. C., & Kramer, M. (1986). Mental health and social characteristics of the homeless: a survey of mission users. *Am J Public Health, 76*(5), 519-524.

Fizmaurice, G., Laird, N., & Ware, J. (2011). *Applied Longitudinal Analysis, 2nd Edition*: John Wiley & Sons.

Fraze, T. K., Brewster, A. L., Lewis, V. A., Beidler, L. B., Murray, G. F., & Colla, C. H. (2019). Prevalence of Screening for Food Insecurity, Housing Instability, Utility Needs, Transportation Needs, and Interpersonal Violence by U.S. Physician Practices and Hospitals. *JAMA Netw Open, 2*(9), e1911514. doi:10.1001/jamanetworkopen.2019.11514

Gallagher, T. C., Andersen, R. M., Koegel, P., & Gelberg, L. (1997). Determinants of regular source of care among homeless adults in Los Angeles. *Med Care, 35*(8), 814-830.

Gamache, G., Rosenheck, R., & Tessler, R. (2001). The proportion of veterans among homeless men: a decade later. *Soc Psychiatry Psychiatr Epidemiol, 36*(10), 481-485.

Gamache, G., Rosenheck, R., & Tessler, R. (2003). Overrepresentation of women veterans among homeless women. *Am J Public Health, 93*(7), 1132-1136.

Garfield, R., Damico, A., & Orgera, K. (2018, 6/12/2018). The Coverage Gap: Uninsured Poor Adults in States that Do Not Expand Medicaid. Retrieved from https://www.kff.org/medicaid/issue-brief/the-coverage-gap-uninsured-poor-adults-in-states-that-do-not-expand-medicaid/

Gelberg, L., Andersen, R. M., & Leake, B. D. (2000). The Behavioral Model for Vulnerable Populations: application to medical care use and outcomes for homeless people. *Health Serv Res, 34*(6), 1273-1302.

Gelberg, L., Gallagher, T. C., Andersen, R. M., & Koegel, P. (1997). Competing priorities as a barrier to medical care among homeless adults in Los Angeles. *Am J Public Health, 87*(2), 217-220.

Giannouchos, T. V., Washburn, D. J., Kum, H. C., Sage, W. M., & Ohsfeldt, R. L. (2019). Predictors of Multiple Emergency Department Utilization Among Frequent Emergency Department Users in 3 States. *Med Care*. doi:10.1097/mlr.0000000000001228

Gilmer, T. P. (2016). Permanent Supportive Housing for Transition-Age Youths: Service Costs and Fidelity to the Housing First Model. *Psychiatr Serv, 67*(6), 615-621. doi:10.1176/appi.ps.201500200

Gilmer, T. P., Manning, W. G., & Ettner, S. L. (2009). A cost analysis of San Diego County's REACH program for homeless persons. *Psychiatr Serv, 60*(4), 445-450. doi:10.1176/appi.ps.60.4.445

Gladwell, M. (2006, 2/13/2006). Million-Dollar Murray. *The New Yorker, 82*.

Glanz, J. M., Narwaney, K. J., Mueller, S. R., Gardner, E. M., Calcaterra, S. L., Xu, S., . . . Binswanger, I. A. (2018). Prediction Model for Two-Year Risk of Opioid Overdose Among Patients Prescribed Chronic Opioid Therapy. *J Gen Intern Med, 33*(10), 1646-1653. doi:10.1007/s11606-017-4288-3

Gregersen, F. A. (2014). The impact of ageing on health care expenditures: a study of steepening. *Eur J Health Econ, 15*(9), 979-989. doi:10.1007/s10198-013-0541-9

Gwira Baumblatt, J. A., Wiedeman, C., Dunn, J. R., Schaffner, W., Paulozzi, L. J., & Jones, T. F. (2014). High-risk use by patients prescribed opioids for pain and its role in overdose deaths. *JAMA Intern Med, 174*(5), 796-801. doi:10.1001/jamainternmed.2013.12711

Hadley, J. (2007). Insurance coverage, medical care use, and short-term health changes following an unintentional injury or the onset of a chronic condition. *Jama, 297*(10), 1073-1084. doi:10.1001/jama.297.10.1073

Hall, A. J., Logan, J. E., Toblin, R. L., Kaplan, J. A., Kraner, J. C., Bixler, D., . . . Paulozzi, L. J. (2008). Patterns of abuse among unintentional pharmaceutical overdose fatalities. *Jama, 300*(22), 2613-2620. doi:10.1001/jama.2008.802

Halm, E. A., Lee, C., & Chassin, M. R. (2002). Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. *Ann Intern Med, 137*(6), 511-520.

Hammig, B., Jozkowski, K., & Jones, C. (2014). Injury-related visits and comorbid conditions among homeless persons presenting to emergency departments. *Acad Emerg Med, 21*(4), 449-455. doi:10.1111/acem.12343

Hastings, S. N., Smith, V. A., Weinberger, M., Oddone, E. Z., Olsen, M. K., & Schmader, K. E. (2013). Health services use of older veterans treated and released from veterans affairs medical center emergency departments. *J Am Geriatr Soc, 61*(9), 1515-1521. doi:10.1111/jgs.12417

Hayward, R. M., Foster, E., & Tseng, Z. H. (2017). Maternal and Fetal Outcomes of Admission for Delivery in Women With Congenital Heart Disease. *JAMA Cardiol, 2*(6), 664-671. doi:10.1001/jamacardio.2017.0283

Healthcare Cost and Utilization Project (HCUP). (2008). HCUP Central Distributor SEDD Description of Data Elements - All States. Retrieved from https://www.hcup-us.ahrq.gov/db/vars/sedddistnote.jsp?var=homeless

Healthcare Cost and Utilization Project (HCUP). (2017). HCUP Elixhauser Comorbidity Software. Retrieved from https://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp

Healthcare Cost and Utilization Project (HCUP). (2018). HCUP Databases. Retrieved from https://www.hcup-us.ahrq.gov/databases.jsp

Hellevik, O. (2009). Linear versus logistic regression when the dependent variable is a dichotomy. *Quality & Quantity, 43*(1), 59-74. doi:10.1007/s11135-007-9077-3

Hibbs, J. R., Benner, L., Klugman, L., Spencer, R., Macchia, I., Mellinger, A., & Fife, D. K. (1994). Mortality in a cohort of homeless adults in Philadelphia. *N Engl J Med, 331*(5), 304-309. doi:10.1056/nejm199408043310506

Hirsh, A. T., Hollingshead, N. A., Ashburn-Nardo, L., & Kroenke, K. (2015). The interaction of patient race, provider bias, and clinical ambiguity on pain management decisions. *J Pain, 16*(6), 558-568. doi:10.1016/j.jpain.2015.03.003

Horvitz-Lennon, M., Frank, R. G., Thompson, W., Baik, S. H., Alegria, M., Rosenheck, R. A., & Normand, S. L. (2009). Investigation of racial and ethnic disparities in service utilization among homeless adults with severe mental illnesses. *Psychiatr Serv, 60*(8), 1032-1038. doi:10.1176/appi.ps.60.8.103210.1176/ps.2009.60.8.1032

Horwitz, J. R. (2005). Making profits and providing care: comparing nonprofit, for-profit, and government hospitals. *Health Aff (Millwood), 24*(3), 790-801. doi:10.1377/hlthaff.24.3.790

Hunt, K. A., Weber, E. J., Showstack, J. A., Colby, D. C., & Callaham, M. L. (2006). Characteristics of frequent users of emergency departments. *Ann Emerg Med, 48*(1), 1-8. doi:10.1016/j.annemergmed.2005.12.030

Hwang, A. S., Liu, S. W., Ashburner, J. M., Auerbach, B. J., Atlas, S. J., & Hong, C. S. (2015). Outcomes of primary care patients who are frequent and persistent users of the ED. *Am J Emerg Med, 33*(9), 1320-1322. doi:10.1016/j.ajem.2015.05.042

Hwang, S. W., Chambers, C., Chiu, S., Katic, M., Kiss, A., Redelmeier, D. A., & Levinson, W. (2013). A comprehensive assessment of health care utilization among homeless adults under a system of universal health insurance. *Am J Public Health, 103 Suppl 2,* S294-301. doi:10.2105/ajph.2013.301369

Hwang, S. W., & Henderson, M. J. (2010). *Health Care Utilization in Homeless People: Translating Research into Policy and Practice*. Agency for Healthcare Research and Quality Working Paper, (10002).

Hwang, S. W., Orav, E. J., O'Connell, J. J., Lebow, J. M., & Brennan, T. A. (1997). Causes of death in homeless adults in Boston. *Ann Intern Med, 126*(8), 625-628.

Hwang, S. W., Weaver, J., Aubry, T., & Hoch, J. S. (2011). Hospital costs and length of stay among homeless patients admitted to medical, surgical, and psychiatric services. *Med Care, 49*(4), 350-354. doi:10.1097/MLR.0b013e318206c50d

Hylan, T. R., Von Korff, M., Saunders, K., Masters, E., Palmer, R. E., Carrell, D., . . . Gross, D. (2015). Automated prediction of risk for problem opioid use in a primary care setting. *J Pain, 16*(4), 380-387. doi:10.1016/j.jpain.2015.01.011

Iheanacho, T., Stefanovics, E., & Rosenheck, R. (2018). Opioid use disorder and homelessness in the Veterans Health Administration: The challenge of multimorbidity. *J Opioid Manag, 14*(3), 171-182. doi:10.5055/jom.2018.0447

Institute of Medicine. (2004). Insuring America's health: principles and recommendations. *Acad Emerg Med, 11*(4), 418-422.

Institute of Medicine Committee on Health Care for Homeless People. (1988). In *Homelessness, Health, and Human Needs*. Washington (D.C.): National Academies Press (U.S.).

Ives, T. J., Chelminski, P. R., Hammett-Stabler, C. A., Malone, R. M., Perhac, J. S., Potisek, N. M., . . . Pignone, M. P. (2006). Predictors of opioid misuse in patients with chronic pain: a prospective cohort study. *BMC Health Serv Res, 6*, 46. doi:10.1186/1472-6963-6-46

Johnson, T. P., & Fendrich, M. (2007). Homelessness and drug use: evidence from a community sample. *Am J Prev Med, 32*(6 Suppl), S211-218. doi:10.1016/j.amepre.2007.02.015

Johnson, T. P., Freels, S. A., Parsons, J. A., & Vangeest, J. B. (1997). Substance abuse and homelessness: social selection or social adaptation? *Addiction, 92*(4), 437-445.

Kaiser Family Foundation. (2014). How Will the Uninsured in Massachusetts Fare Under the Affordable Care Act? Retrieved from https://www.kff.org/health-reform/fact-sheet/state-profiles-uninsured-under-aca-massachusetts/

Kaiser Family Foundation. (2015). Gender Differences in Health Care, Status, and Use: Spotlight on Men's Health. Retrieved from https://www.kff.org/womens-health-policy/fact-sheet/gender-differences-in-health-care-status-and-use-spotlight-on-mens-health/

Kaiser Family Foundation. (2020). Status of State Action on the Medicaid Expansion Decision. Retrieved from https://www.kff.org/health-reform/state-indicator/state-activity-around-expanding-medicaid-under-the-affordable-care-act/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D

Kanzaria, H. K., Niedzwiecki, M., Cawley, C. L., Chapman, C., Sabbagh, S. H., Riggs, E., . . . Raven, M. C. (2019). Frequent Emergency Department Users: Focusing Solely On Medical Utilization Misses The Whole Person. *Health Aff (Millwood), 38*(11), 1866-1875. doi:10.1377/hlthaff.2019.00082

Karaca, Z., Wong, H. S., & Mutter, R. L. (2013). Characteristics of Homeless and Non-Homeless Individuals Using Inpatient and Emergency Department Services, 2008: Statistical Brief #152. In *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. Rockville (M.D.): Agency for Healthcare Research and Quality (U.S.).

Kertesz, S. G., Posner, M. A., O'Connell, J. J., Swain, S., Mullins, A. N., Shwartz, M., & Ash, A. S. (2009). Post-hospital medical respite care and hospital readmission of homeless persons. *J Prev Interv Community, 37*(2), 129-142. doi:10.1080/10852350902735734

Killion, C. M. (1995). Special health care needs of homeless pregnant women. *ANS Adv Nurs Sci, 18*(2), 44-56. doi:10.1097/00012272-199512000-00006

Kirst, M., Zerger, S., Misir, V., Hwang, S., & Stergiopoulos, V. (2015). The impact of a Housing First randomized controlled trial on substance use problems among homeless individuals with mental illness. *Drug Alcohol Depend, 146*, 24-29. doi:10.1016/j.drugalcdep.2014.10.019

Klein, J. D., Woods, A. H., Wilson, K. M., Prospero, M., Greene, J., & Ringwalt, C. (2000). Homeless and runaway youths' access to health care. *J Adolesc Health, 27*(5), 331-339.

Koegel, P., & Burnam, M. A. (1988). Alcoholism among homeless adults in the inner city of Los Angeles. *Arch Gen Psychiatry, 45*(11), 1011-1018.

Koh, K. A., Racine, M., Gaeta, J. M., Goldie, J., Martin, D. P., Bock, B., . . . Song, Z. (2020). Health Care Spending And Use Among People Experiencing Unstable Housing In The Era Of Accountable Care Organizations. *Health Aff (Millwood), 39*(2), 214-223. doi:10.1377/hlthaff.2019.00687

Kramer, M. S. (2003). The epidemiology of adverse pregnancy outcomes: an overview. *J Nutr, 133*(5 Suppl 2), 1592s-1596s. doi:10.1093/jn/133.5.1592S

Ku, B. S., Fields, J. M., Santana, A., Wasserman, D., Borman, L., & Scott, K. C. (2014). The urban homeless: super-users of the emergency department. *Popul Health Manag, 17*(6), 366-371. doi:10.1089/pop.2013.0118

Ku, B. S., Scott, K. C., Kertesz, S. G., & Pitts, S. R. (2010). Factors associated with use of urban emergency departments by the U.S. homeless population. *Public Health Rep, 125*(3), 398-405. doi:10.1177/003335491012500308

Kuklina, E. V., Whiteman, M. K., Hillis, S. D., Jamieson, D. J., Meikle, S. F., Posner, S. F., & Marchbanks, P. A. (2008). An enhanced method for identifying obstetric deliveries: implications for estimating maternal morbidity. *Matern Child Health J, 12*(4), 469-477. doi:10.1007/s10995-007-0256-6

Kushel, M. B., Perry, S., Bangsberg, D., Clark, R., & Moss, A. R. (2002). Emergency department use among the homeless and marginally housed: results from a community-based study. *Am J Public Health, 92*(5), 778-784.

Kushel, M. B., Vittinghoff, E., & Haas, J. S. (2001). Factors associated with the health care utilization of homeless persons. *Jama, 285*(2), 200-206.

LaCalle, E., & Rabin, E. (2010). Frequent users of emergency departments: the myths, the data, and the policy implications. *Ann Emerg Med, 56*(1), 42-48. doi:10.1016/j.annemergmed.2010.01.032

Larimer, M. E., Malone, D. K., Garner, M. D., Atkins, D. C., Burlingham, B., Lonczak, H. S., . . . Marlatt, G. A. (2009). Health care and public service use and costs before and after provision of housing for chronically homeless persons with severe alcohol problems. *Jama, 301*(13), 1349-1357. doi:10.1001/jama.2009.414

Larochelle, M. R., Zhang, F., Ross-Degnan, D., & Wharam, J. F. (2015). Rates of opioid dispensing and overdose after introduction of abuse-deterrent extended-release oxycodone and withdrawal of propoxyphene. *JAMA Intern Med, 175*(6), 978-987. doi:10.1001/jamainternmed.2015.0914

Lassman, D., Hartman, M., Washington, B., Andrews, K., & Catlin, A. (2014). US health spending trends by age and gender: selected years 2002-10. *Health Aff (Millwood), 33*(5), 815-822. doi:10.1377/hlthaff.2013.1224

Lewis, J. H., Andersen, R. M., & Gelberg, L. (2003). Health care for homeless women. *J Gen Intern Med, 18*(11), 921-928.

Li, F., Morgan, K. L., & Zaslavsky, A. M. (2018). Balancing Covariates via Propensity Score Weighting. *Journal of the American Statistical Association, 113*(521), 390-400. doi:10.1080/01621459.2016.1260466

Li, F., Thomas, L. E., & Li, F. (2019). Addressing Extreme Propensity Scores via the Overlap Weights. *Am J Epidemiol, 188*(1), 250-257. doi:10.1093/aje/kwy201

Lim, S., Gao, Q., Stazesky, E., Singh, T. P., Harris, T. G., & Levanon Seligson, A. (2018). Impact of a New York City supportive housing program on Medicaid expenditure patterns among people with serious mental illness and chronic homelessness. *BMC Health Serv Res, 18*(1), 15. doi:10.1186/s12913-017-2816-9

Lin, D. Y., Psaty, B. M., & Kronmal, R. A. (1998). Assessing the sensitivity of regression results to unmeasured confounders in observational studies. *Biometrics, 54*(3), 948-963.

Lin, W. C., Bharel, M., Zhang, J., O'Connell, E., & Clark, R. E. (2015). Frequent Emergency Department Visits and Hospitalizations Among Homeless People With Medicaid: Implications for Medicaid Expansion. *Am J Public Health, 105 Suppl 5*, S716-722. doi:10.2105/ajph.2015.302693

Little, M., Shah, R., Vermeulen, M. J., Gorman, A., Dzendoletas, D., & Ray, J. G. (2005). Adverse perinatal outcomes associated with homelessness and substance use in pregnancy. *Cmaj, 173*(6), 615-618. doi:10.1503/cmaj.050406

Lo-Ciganic, W. H., Huang, J. L., Zhang, H. H., Weiss, J. C., Wu, Y., Kwoh, C. K., . . . Gellad, W. F. (2019). Evaluation of Machine-Learning Algorithms for Predicting Opioid Overdose Risk Among Medicare Beneficiaries With Opioid Prescriptions. *JAMA Netw Open, 2*(3), e190968. doi:10.1001/jamanetworkopen.2019.0968

Manzano-Nunez, R., Zogg, C. K., Bhulani, N., McCarty, J. C., Herrera-Escobar, J. P., Lu, K., . . . Ortega, G. (2019). Association of Medicaid Expansion Policy with Outcomes in Homeless Patients Requiring Emergency General Surgery. *World J Surg, 43*(6), 1483-1489. doi:10.1007/s00268-019-04932-0

Marshall, J. R., Gassner, S. F., Anderson, C. L., Cooper, R. J., Lotfipour, S., & Chakravarthy, B. (2018). Socioeconomic and geographical disparities in prescription and illicit opioid-related overdose deaths in Orange County, California, from 2010-2014. *Subst Abus*, 1-7. doi:10.1080/08897077.2018.1442899

McConville, S., Raven, M. C., Sabbagh, S. H., & Hsia, R. Y. (2018). Frequent Emergency Department Users: A Statewide Comparison Before And After Affordable Care Act Implementation. *Health Aff (Millwood), 37*(6), 881-889. doi:10.1377/hlthaff.2017.0784

Meges, D., Zevin, B., Cookson, E., Bascelli, L., Denning, P., Little, J., . . . Post, P. E. (2014). *Adapting Your Practice: Recommendations for the Care of Homeless Patients with Opioid Use Disorders*. Retrieved from Nashville, TN:

Midboe, A. M., Byrne, T., Smelson, D., Jasuja, G., McInnes, K., & Troszak, L. K. (2019). The Opioid Epidemic In Veterans Who Were Homeless Or Unstably Housed. *Health Aff (Millwood), 38*(8), 1289-1297. doi:10.1377/hlthaff.2019.00281

Miller, G. E., & Moriya, A. S. (2018). Any Use and Frequent Use of Opioids among Non-Elderly Adults in 2015-2016, by Socioeconomic Characteristics. In *Statistical Brief (Medical Expenditure Panel Survey (US))*. Rockville (MD): Agency for Healthcare Research and Quality (US).

Miller-Archie, S. A., Walters, S. C., Singh, T. P., & Lim, S. (2019). Impact of supportive housing on substance use-related health care utilization among homeless persons who are active substance users. *Ann Epidemiol, 32*, 1-6.e1. doi:10.1016/j.annepidem.2019.02.002

Mitchell, M. S., Leon, C. L. K., Byrne, T. H., Lin, W. C., & Bharel, M. (2017). Cost of health care utilization among homeless frequent emergency department users. *Psychol Serv, 14*(2), 193-202. doi:10.1037/ser0000113

Mojtabai, R. (2005). Perceived reasons for loss of housing and continued homelessness among homeless persons with mental illness. *Psychiatr Serv, 56*(2), 172-178. doi:10.1176/appi.ps.56.2.172

Montgomery, A. E., Szymkowiak, D., Marcus, J., Howard, P., & Culhane, D. P. (2016). Homelessness, Unsheltered Status, and Risk Factors for Mortality: Findings From the 100 000 Homes Campaign. *Public Health Rep, 131*(6), 765-772. doi:10.1177/0033354916667501

National Alliance to End Homelessness. (2020). Federal Funding for Homelessness Programs. Retrieved from https://endhomelessness.org/ending-homelessness/policy/federal-funding-homelessness-programs/

National Coalition for the Homeless. (2009). How Many People Experience Homelessness. Retrieved from http://nationalhomeless.org/wp-content/uploads/2017/09/HowManyPeople.pdf

National Coalition for the Homeless. (2017). Substance Abuse and Homelessness. Retrieved from https://nationalhomeless.org/wp-content/uploads/2017/06/Substance-Abuse-and-Homelessness.pdf

National Health Care for the Homeless Council and Health Care for the Homeless Clinicians' Network Research Coordinating Committee. (2005). *Research Agenda Homelessness and Health Care: Summary of Findings*. Retrieved from Nashville TN: https://www.nhchc.org/wp-content/uploads/2011/09/ResearchAgendaFindings.pdf

National Institute on Drug Abuse. (2018). *Overdose Death Rates*. Retrieved from https://www.drugabuse.gov/related-topics/trends-statistics/overdose-death-rates

Nielsen, S. F., Hjorthoj, C. R., Erlangsen, A., & Nordentoft, M. (2011). Psychiatric disorders and mortality among people in homeless shelters in Denmark: a nationwide register-based cohort study. *Lancet, 377*(9784), 2205-2214. doi:10.1016/s0140-6736(11)60747-2

Norris, L. (2017). New York and the ACA's Medicaid expansion. Retrieved from https://www.healthinsurance.org/new-york-medicaid/

Norris, L. (2018). Maryland and the ACA's Medicaid expansion. Retrieved from https://www.healthinsurance.org/maryland-medicaid/

Norton, E. C., & Staiger, D. O. (1994). How hospital ownership affects access to care for the uninsured. *Rand J Econ, 25*(1), 171-185.

Nunez, R., & Cox, C. (1999). A snapshot of family homelessness across America. *Political Science Quarterly, 114*, 289-299.

O'Connell, J. J., Roncarati, J. S., Reilly, E. C., Kane, C. A., Morrison, S. K., Swain, S. E., . . . Jones, K. (2004). Old and sleeping rough: elderly homeless persons on the streets of Boston. *Care Manag J, 5*(2), 101-106.

Oates, G., Tadros, A., & Davis, S. M. (2009). A comparison of National Emergency Department use by homeless versus non-homeless people in the United States. *J Health Care Poor Underserved, 20*(3), 840-845. doi:10.1353/hpu.0.0192

Oliva, E. M., Bowe, T., Tavakoli, S., Martins, S., Lewis, E. T., Paik, M., . . . Trafton, J. A. (2017). 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, 14*(1), 34-49. doi:10.1037/ser0000099

Padgett, D. K., Struening, E. L., Andrews, H., & Pittman, J. (1995). Predictors of emergency room use by homeless adults in New York City: the influence of predisposing, enabling and need factors. *Soc Sci Med, 41*(4), 547-556.

Parpouchi, M., Moniruzzaman, A., Rezansoff, S. N., Russolillo, A., & Somers, J. M. (2017). Characteristics of adherence to methadone maintenance treatment over a 15-year period among homeless adults experiencing mental illness. *Addict Behav Rep, 6*, 106-111. doi:10.1016/j.abrep.2017.09.001

Paterson, C. M., & Roderick, P. (1990). Obstetric outcome in homeless women. *Bmj, 301*(6746), 263-266. doi:10.1136/bmj.301.6746.263

Perlman, J., & Parvensky, J. (2006). *Denver Housing First Collaborative: Cost Benefit Analysis and Program Outcomes Report*. Retrieved from https://shnny.org/uploads/Supportive_Housing_in_Denver.pdf

Price, M. (2009). More than shelter*40*, 58. Retrieved from http://www.apa.org/monitor/2009/12/shelter.aspx

Quigley, J. M., Raphael, S., Smolensky, E., Mansur, E., & Rosenthal, L. A. (2001). *Homelessness in California*. Retrieved from San Francisco, CA: https://urbanpolicy.berkeley.edu/pdf/ppic_homeless.pdf

Rice, J. B., White, A. G., Birnbaum, H. G., Schiller, M., Brown, D. A., & Roland, C. L. (2012). A model to identify patients at risk for prescription opioid abuse, dependence, and misuse. *Pain Med, 13*(9), 1162-1173. doi:10.1111/j.1526-4637.2012.01450.x

Richards, R., Merrill, R. M., & Baksh, L. (2011). Health behaviors and infant health outcomes in homeless pregnant women in the United States. *Pediatrics, 128*(3), 438-446. doi:10.1542/peds.2010-3491

Ronald O. Perelman Department of Emergency Department. Current Research Initiatives: Social Determinants of Health. Retrieved from https://med.nyu.edu/emergency/research/current-research-initiatives/social-determinants-health

Rose, A. J., Bernson, D., Chui, K. K. H., Land, T., Walley, A. Y., LaRochelle, M. R., . . . Stopka, T. J. (2018). Potentially Inappropriate Opioid Prescribing, Overdose, and Mortality in Massachusetts, 2011-2015. *J Gen Intern Med, 33*(9), 1512-1519. doi:10.1007/s11606-018-4532-5

Rosenbloom, J. M., Burns, S. M., Kim, E., August, D. A., Ortiz, V. E., & Houle, T. T. (2018). Race/Ethnicity and Sex Both Affect Opioid Administration in the Emergency Room. *Anesth Analg*. doi:10.1213/ane.0000000000003517

Rosendale, N., Guterman, E. L., Betjemann, J. P., Josephson, S. A., & Douglas, V. C. (2019). Hospital admission and readmission among homeless patients with neurologic disease. *Neurology, 92*(24), e2822-e2831. doi:10.1212/wnl.0000000000007645

Ruger, J. P., Richter, C. J., Spitznagel, E. L., & Lewis, L. M. (2004). Analysis of costs, length of stay, and utilization of emergency department services by frequent users: implications for health policy. *Acad Emerg Med, 11*(12), 1311-1317. doi:10.1197/j.aem.2004.07.008

Saab, D., Nisenbaum, R., Dhalla, I., & Hwang, S. W. (2016). Hospital Readmissions in a Community-based Sample of Homeless Adults: a Matched-cohort Study. *J Gen Intern Med, 31*(9), 1011-1018. doi:10.1007/s11606-016-3680-8

Schanzer, B., Dominguez, B., Shrout, P. E., & Caton, C. L. (2007). Homelessness, health status, and health care use. *Am J Public Health, 97*(3), 464-469. doi:10.2105/ajph.2005.076190

Shaban, B., Campos, R., Rutanashoodech, A., Villarreal, M., & Carroll, J. (2017, 11/14/2017). Rising Number of Homeless Newborns, Pregnant Women Struggling in San Francisco. *NBC Bay Area*. Retrieved from https://www.nbcbayarea.com/news/local/number-homeless-pregnant-women-newborns-on-the-rise-in-san-francisco/37786/

Shah, N. G., Galai, N., Celentano, D. D., Vlahov, D., & Strathdee, S. A. (2006). Longitudinal predictors of injection cessation and subsequent relapse among a cohort of injection drug users in Baltimore, MD, 1988-2000. *Drug Alcohol Depend, 83*(2), 147-156. doi:10.1016/j.drugalcdep.2005.11.007

Shelton, K. H., Taylor, P. J., Bonner, A., & van den Bree, M. (2009). Risk factors for homelessness: evidence from a population-based study. *Psychiatr Serv, 60*(4), 465-472. doi:10.1176/appi.ps.60.4.465

Smith, O. M., Chant, C., Burns, K. E. A., Kaur, M., Ashraf, S., DosSantos, C. C., . . . Friedrich, J. O. (2017). Characteristics, clinical course, and outcomes of homeless and non-homeless patients admitted to ICU: A retrospective cohort study. *PLoS One, 12*(6), e0179207. doi:10.1371/journal.pone.0179207

Stein, J. A., Andersen, R., & Gelberg, L. (2007). Applying the Gelberg-Andersen behavioral model for vulnerable populations to health services utilization in homeless women. *J Health Psychol, 12*(5), 791-804. doi:10.1177/1359105307080612

Stein, J. A., Lu, M. C., & Gelberg, L. (2000). Severity of homelessness and adverse birth outcomes. *Health Psychol, 19*(6), 524-534.

Sullivan, M. D., Edlund, M. J., Fan, M. Y., Devries, A., Brennan Braden, J., & Martin, B. C. (2010). Risks for possible and probable opioid misuse among recipients of chronic opioid therapy in commercial and medicaid insurance plans: The TROUP Study. *Pain, 150*(2), 332-339. doi:10.1016/j.pain.2010.05.020

Sun, B. C., Burstin, H. R., & Brennan, T. A. (2003). Predictors and outcomes of frequent emergency department users. *Acad Emerg Med, 10*(4), 320-328. doi:10.1111/j.1553-2712.2003.tb01344.x

Sun, R., Karaca, Z., & Wong, H. S. (2006). Characteristics of Homeless Individuals Using Emergency Department Services in 2014: Statistical Brief #229. In *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. Rockville (M.D.): Agency for Healthcare Research and Quality (U.S.).

Tadros, A., Layman, S. M., Brewer, M. P., & Davis, S. M. (2016). A 5-year comparison of ED visits by homeless and nonhomeless patients. *Am J Emerg Med, 34*(5), 805-808. doi:10.1016/j.ajem.2016.01.012

Thakarar, K., Morgan, J. R., Gaeta, J. M., Hohl, C., & Drainoni, M. L. (2015). Predictors of Frequent Emergency Room Visits among a Homeless Population. *PLoS One, 10*(4), e0124552. doi:10.1371/journal.pone.0124552

The Homeless Hub. (2017). Causes of Homelessness. Retrieved from http://homelesshub.ca/about-homelessness/homelessness-101/causes-homelessness

The US Department of Housing and Urban Development. (2018). *The 2018 Annual Homeless Assessment Report (AHAR) to Congree*. Washington D.C Retrieved from https://www.hudexchange.info/resources/documents/2018-AHAR-Part-1.pdf.

Thomas, L. E., Li, F., & Pencina, M. J. (2020). Overlap Weighting: A Propensity Score Method That Mimics Attributes of a Randomized Clinical Trial. *Jama*. doi:10.1001/jama.2020.7819

Tikkanen, M. (2011). Placental abruption: epidemiology, risk factors and consequences. *Acta Obstet Gynecol Scand, 90*(2), 140-149. doi:10.1111/j.1600-0412.2010.01030.x

Tsai, J., Doran, K. M., & Rosenheck, R. A. (2013). When health insurance is not a factor: national comparison of homeless and nonhomeless US veterans who use Veterans Affairs Emergency Departments. *Am J Public Health, 103 Suppl 2*, S225-231. doi:10.2105/ajph.2013.301307

Tsai, J., Link, B., Rosenheck, R. A., & Pietrzak, R. H. (2016). Homelessness among a nationally representative sample of US veterans: prevalence, service utilization, and correlates. *Soc Psychiatry Psychiatr Epidemiol, 51*(6), 907-916. doi:10.1007/s00127-016-1210-y

Tsai, J., & Rosenheck, R. A. (2013). Risk factors for ED use among homeless veterans. *Am J Emerg Med, 31*(5), 855-858. doi:10.1016/j.ajem.2013.02.046

Tsemberis, S., & Eisenberg, R. F. (2000). Pathways to housing: supported housing for street-dwelling homeless individuals with psychiatric disabilities. *Psychiatr Serv, 51*(4), 487-493. doi:10.1176/appi.ps.51.4.487

Tsemberis, S., Gulcur, L., & Nakae, M. (2004). Housing First, consumer choice, and harm reduction for homeless individuals with a dual diagnosis. *Am J Public Health, 94*(4), 651-656.

U.S. Department of Housing and Urban Development. (2014). *The 2014 Annual Homeless Assessment Report (AHAR) to Congress*. Washington D.C. Retrieved from https://files.hudexchange.info/resources/documents/2014-AHAR-Part1.pdf.

U.S. Department of Housing and Urban Development. (2017). *The 2017 Annual Homeless Assessment Report (AHAR) to Congress*. Washington D.C. Retrieved from https://www.hudexchange.info/resources/documents/2017-AHAR-Part-1.pdf.

U.S. Department of Housing and Urban Development. (2019). *The 2019 Annual Homeless Assessment Report (AHAR) to Congress*. Washington D.C. Retrieved from https://files.hudexchange.info/resources/documents/2019-AHAR-Part-1.pdf.

Upshur, C. C., Jenkins, D., Weinreb, L., Gelberg, L., & Orvek, E. A. (2018). Homeless women's service use, barriers, and motivation for participating in substance use treatment. *Am J Drug Alcohol Abuse, 44*(2), 252-262. doi:10.1080/00952990.2017.1357183

Vangeest, J. B., & Johnson, T. P. (2002). Substance abuse and homelessness: direct or indirect effects? *Ann Epidemiol, 12*(7), 455-461.

Vijayaraghavan, M., Penko, J., Bangsberg, D. R., Miaskowski, C., & Kushel, M. B. (2013). Opioid analgesic misuse in a community-based cohort of HIV-infected indigent adults. *JAMA Intern Med, 173*(3), 235-237. doi:10.1001/jamainternmed.2013.1576

Wadhera, R. K., Choi, E., Shen, C., Yeh, R. W., & Joynt Maddox, K. E. (2019). Trends, Causes, and Outcomes of Hospitalizations for Homeless Individuals: A Retrospective Cohort Study. *Med Care, 57*(1), 21-27. doi:10.1097/mlr.0000000000001015

Wadhera, R. K., Khatana, S. A. M., Choi, E., Jiang, G., Shen, C., Yeh, R. W., & Joynt Maddox, K. E. (2019). Disparities in Care and Mortality Among Homeless Adults Hospitalized for Cardiovascular Conditions. *JAMA Intern Med*. doi:10.1001/jamainternmed.2019.6010

Wagner, J., Diehl, K., Mutsch, L., Loffler, W., Burkert, N., & Freidl, W. (2014). Health status and utilisation of the healthcare system by homeless and non-homeless people in Vienna. *Health Soc Care Community, 22*(3), 300-307. doi:10.1111/hsc.12083

Webster, L. R., Cochella, S., Dasgupta, N., Fakata, K. L., Fine, P. G., Fishman, S. M., . . . Wakeland, W. (2011). An analysis of the root causes for opioid-related overdose deaths in the United States. *Pain Med, 12 Suppl 2*, S26-35. doi:10.1111/j.1526-4637.2011.01134.x

Webster, L. R., & Webster, R. M. (2005). Predicting aberrant behaviors in opioid-treated patients: preliminary validation of the Opioid Risk Tool. *Pain Med, 6*(6), 432-442. doi:10.1111/j.1526-4637.2005.00072.x

Weiss, A. J., & Heslin, K. C. (2006). Payers of Opioid-Related Inpatient Stays and Emergency Department Visits Nationally and by State, 2010 and 2015: Statistical Brief #239. In *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. Rockville (MD): Agency for Healthcare Research and Quality (US).

Welch-Lazoritz, M. L., Whitbeck, L. B., & Armenta, B. E. (2015). Characteristics of Mothers Caring for Children During Episodes of Homelessness. *Community Ment Health J, 51*(8), 913-920. doi:10.1007/s10597-014-9794-8

White, A. G., Birnbaum, H. G., Schiller, M., Tang, J., & Katz, N. P. (2009). Analytic models to identify patients at risk for prescription opioid abuse. *Am J Manag Care, 15*(12), 897-906.

White, B., Ellis, C., Jones, W., Moran, W., & Simpson, K. (2018). The effect of the global financial crisis on preventable hospitalizations among the homeless in New York State. *J Health Serv Res Policy, 23*(2), 80-86. doi:10.1177/1355819617742180

White, B. M., Ellis, C., Jr., & Simpson, K. N. (2014). Preventable hospital admissions among the homeless in California: a retrospective analysis of care for ambulatory care sensitive conditions. *BMC Health Serv Res, 14*, 511. doi:10.1186/s12913-014-0511-7

Wiley, L. K., Shah, A., Xu, H., & Bush, W. S. (2013). ICD-9 tobacco use codes are effective identifiers of smoking status. *J Am Med Inform Assoc, 20*(4), 652-658. doi:10.1136/amiajnl-2012-001557

Williams, R. (2012). Using the margins command to estimate and interpret adjusted predictions and marginal effects. *The Stata Journal, 12*(2), 308 - 331.

Wright, B. J., Vartanian, K. B., Li, H. F., Royal, N., & Matson, J. K. (2016). Formerly Homeless People Had Lower Overall Health Care Expenditures After Moving Into Supportive Housing. *Health Aff (Millwood), 35*(1), 20-27. doi:10.1377/hlthaff.2015.0393

Zedler, B., Xie, L., Wang, L., Joyce, A., Vick, C., Brigham, J., . . . Murrelle, L. (2015). Development of a Risk Index for Serious Prescription Opioid-Induced Respiratory Depression or Overdose in Veterans' Health Administration Patients. *Pain Med, 16*(8), 1566-1579. doi:10.1111/pme.12777

Zedler, B. K., Saunders, W. B., Joyce, A. R., Vick, C. C., & Murrelle, E. L. (2018). 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, 19*(1), 68-78. doi:10.1093/pm/pnx009

Zhong, Q. Y., Gelaye, B., Fricchione, G. L., Avillach, P., Karlson, E. W., & Williams, M. A. (2018). Adverse obstetric and neonatal outcomes complicated by psychosis among pregnant women in the United States. *BMC Pregnancy Childbirth, 18*(1), 120. doi:10.1186/s12884-018-1750-0

Zur, J., & Tolbert, J. (2018). The Role of Community Health Centers in Addressing the Opioid Epidemic. Retrieved from https://www.kff.org/medicaid/issue-brief/the-role-of-community-health-centers-in-addressing-the-opioid-epidemic/