



Multilevel Risk Factors for Hospital Readmission Among Patients With Opioid Use Disorder in Selected US States: Role of Socioeconomic Characteristics of Patients and Their Community

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Abstract

Research Objective: Using a multilevel framework, the study examines the association of socioeconomic characteristics of the individual and the community with all-cause 30-day readmission risks for patients hospitalized with a principal diagnosis of opioid use disorder (OUD).

Study Design: The study uses hospital discharge data of adult (18+) patients in 5 US states for 2014 from the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality, linked to community and hospital characteristics using data from Health Resources and Services Administration and American Hospital Association, respectively. A multilevel logistic regression model is applied on data pooled over 5 states adjusting for patient, hospital, and community characteristics.

Principal Findings: Higher primary care access, as measured by density of primary care providers, is associated with reduced readmission risks among patients with OUD. Medicare is associated with the highest readmission risk (odds ratio [OR] = 2.0, $P < .01$) compared to private coverage, while Medicaid coverage is also associated with elevated risk (OR = 1.71, $P < .01$). Being self-pay or covered by other payers carried a similar risk to private coverage. Urban patients had higher readmission rates than rural patients.

Conclusions: Patients' risk of readmission following hospitalization for OUD varies according to availability of primary care providers, expected payer, and geographic location. Understanding which patients are most at risk may allow policy makers to design interventions to prevent readmissions and improve patient outcomes. Future studies may wish to focus on understanding when a decreased readmission rate represents better patient outcomes and when it represents difficulty accessing health care.

Keywords

access to care, health outcomes, hospital readmissions, opioid use, disorder, multilevel analysis, risk predictions

Introduction

Opioid use disorder (OUD) is a nationally significant public health threat. Two million people have an OUD and 47 000 people died from opioids in 2017.¹ As the numbers of people with OUD have increased, so have hospitalizations related to opioids. Opioid-related hospitalizations increased by over 20% from 2011 to 2014.^{2,3} Rate of inpatient stays due to opioid-related hospitalizations per 100,000 population increased from 197.1 in 2010 to 224.6 and 296.9 in 2014 and 2016, respectively.⁴

Patients with a history of opioid use prior to hospitalization are more likely to die in hospital and more likely to be readmitted within 30 days of discharge compared to patients without such a history. Identifying patients at high risk of

readmission and targeting them for additional support and resources is an effective strategy for improving patient outcomes. However, there are only limited data for assessing readmission risks for patients admitted in the hospital with an OUD. Readmissions occur because of a complex set of factors, some of which are patient-specific and some of which may be

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attributable to hospital quality and contextual factors,⁵ and existing studies do not provide an adequate understanding of drivers of readmission risks for patients admitted with an opioid-related disorder. Our study fills this gap by linking patient-, hospital-, and community-level information to provide a comprehensive description of readmission risks among such patients. Understanding which patients are most at risk may allow policy makers to design interventions to prevent readmissions and improve patient outcomes.

The study focuses on patients in 5 US states who were admitted with a principal diagnosis of OUD in 2014. The objectives of the study are to describe these patients and to identify the factors that significantly predict 30-day all-cause readmission risks among such patients. Our primary interest is to examine sociodemographic characteristics of patients admitted with such diagnoses and the contextual characteristics of the community they come from. The association of geography and socioeconomic conditions of the community with opioid-related hospitalizations has been highlighted in recent work.^{2,6,7}

Background

Studies on readmissions following an index admission of OUD to date have focused on the readmission risks of opioid users compared to nonopioid users for specific admission types. For example, Mosher et al⁸ found that patients with acute medical conditions who had received chronic opioid therapy in the 6 months prior to admission were more likely to either die in the hospital or be readmitted within 30 days. Chronic opioid use among patients with cirrhosis was found to be associated with higher all-cause readmissions.⁹ Other recent studies also found OUD and dependence associated with higher readmissions among patients undergoing lumbar fusion, surgery, and traumatic disorder.¹⁰⁻¹³ Three recent studies found strong associations between opioid-related treatment protocols in the inpatient care setting and subsequent risks of opioid-related readmission.¹⁴⁻¹⁶ A number of these studies also focused on admissions and readmissions both related to opioids.^{14,15}

Although the studies mentioned above concur that hospitalization for OUD is associated with increased risks of readmission, none of them, however, examined the interactions between OUD and traditional risk factors associated with 30-day all-cause readmissions. These multilevel risk factors have been identified and validated in previous research on readmissions,^{17,18} using a combination of the Andersen-Newman framework¹⁹ and Structure-Process-Outcomes framework by Aday et al²⁰ and Ashton and Wray.²¹ The importance of using a framework of social determinants of health and health-care utilization has also been emphasized in recent work.²²⁻²⁴

The multilevel conceptual framework accounts for several patient characteristics, community characteristics, and provider characteristics, found important in previous research.¹⁷ Patient characteristics could include predisposing (age, sex, race/ethnicity), enabling (insurance status, income), and need (health status, disease severity) characteristics as used in the traditional models of health-care utilization.²⁰ Community characteristics

are represented by several variables such as primary care access, population density, and urban/rural residential status. The variables representing attributes of the hospitals where patients were initially admitted could include hospital bed size, safety net status, and ownership status, among others.

Objective and Hypotheses

Our study proposes to use the framework mentioned above to assess the role of sociodemographic characteristics of the patients admitted with an OUD diagnosis and their community characteristics. Because we focus on all-cause readmission as the outcome, our framework uses a broad set of possible risk factors that could affect outcome. We assess the independent associations of sociodemographic characteristics of patients and their community with readmissions, after adjusting for the influence of other multilevel factors.

Based on previous research, we make a few hypotheses related to the possible association of readmissions rates with patient/county socioeconomic factors. Studies generally show strong associations between patient's lower socioeconomic status and higher risks of readmissions. Previous research found older patients to have increased encounter with opioid-related hospitalization and rehospitalizations in recent years.³ Both racial ethnic minorities and people without insurance coverage were found to be at increased risks of readmissions in general, although previous research found strong associations between race/ethnicity and insurance coverage in predicting all-cause readmissions,²⁵ with lower readmissions often reflecting financial barrier to access the needed readmission.

Studies also show strong correlations between characteristics of patient's residential areas, including socioeconomic status, rurality, and unemployment rates with increased OUD. Rural areas have higher prevalence of opioids and greater increases in substance abuse than other areas, and areas with higher poverty and unemployment rates generally have higher rates of retail opioid sales and opioid-related hospitalizations.² Based on previous research, we expect patients in areas with lower socioeconomic status to have increased risk of readmissions because of limited access to postdischarge care and disparities in health-care quality.

We also expect increased access to primary care to lead to lower readmissions. This could happen due to the potential availability of better postdischarge care and follow-up care and improved "care transitions," which have been shown to reduce readmission rates.²⁶ Studies also found contrary evidence that better primary care could lead to an increase rather than decrease in the rate of hospital readmissions due to increased primary care physician (PCP) monitoring.^{17,27}

Methods and Study Design

The study uses 2014 State Inpatient Databases (SIDs) from 5 states, collected as part of the Healthcare Cost and Utilization Project (HCUP) data of Agency for Healthcare Research and Quality,²⁸ to identify patients with a diagnosis of OUD under

Table 1. Means of Variables Used in Logistic Regression Model: 5 States Average, 2014.^{a,b}

Patients Admitted With Opioid Use Disorder (OUD) as the Primary Diagnoses (N = 25,561) in the 18 and Above Age-Group	
Average readmission rates	12%
Patient characteristics	
Male (reference)	59%
Female	41%
Age 18-34 (reference)	
35-44	16.57%
45-64	35.32%
65-74	7.07%
75-84	2.33%
85 and older	0.92%
Race (reference: white) ^a	
African American	10.33%
Hispanic	12.42%
Other race	6.49%
# Chronic conditions (reference: 0-1)	
Chrn1 (2-3)	33.01%
Chrn2 (4 and up)	60.27%
Insurance (reference: private pay)	
Medicare	24.51%
Medicaid	44.77%
Uninsured	9.87%
Other pay	3.25%
Patient comorbidity	
Drug abuse	23.97%
Psychoses	24.93%
Depression	21.03%
Alcohol abuse	7.61%
Opioid diagnoses types (reference = opioid-type dependence)	29.5%
Combination of opioid-type drug	9.98%
Opioid abuse	14.51%
Poisoning by opium	45.06%
Poisoning by opium antagonists	0.95%
APR-DRG severity (reference: minor)	
Moderate	40.59%
Major	18.70%
Extreme	11.88%
Admission type (reference: elective)	
Emergency	70.12%
Urgent and other	10.45%
Other patient characteristics	
ALOS (days)	6.15
Admitting hospital characteristics	
Safety net hospital	34.65%
Teaching hospital	64.71%
Bed size (reference: small)	
Medium	24.25%
Large	66.53%
Hospital ownership status	
Government, nonfederal	20.7%
Private, for-profit	65.41%
For-profit, invest-owned	13.89%
Community characteristics	
Rural/urban (reference: metropolitan)	
Micropolitan	19.11%

(continued)

Table 1. (continued)

Patients Admitted With Opioid Use Disorder (OUD) as the Primary Diagnoses (N = 25,561) in the 18 and Above Age-Group	
Small town	5.07%
Rural	2.33%
Median household income national quartile for patient zip code	
US\$0-39,999	30.67%
US\$40,000-49,999	23.13%
US\$50,000-65,999	19.34%
US\$66,000+	26.81%
PCP density (PCPs per 100,000 population) in PCSA: Ref: 0-4/100,000	
5-14	0.81%
15-57	31.36%
58 and up	67.36%
PCSA having patients with at least 1 outpatient visit in the past year	73.03%

Abbreviations: ALOS, average length of stay; APR-DRG, All Patient Refined Diagnostic Related Groups; PCP, primary care physician; PCSA, primary care service area.

^aRounding errors are present in the data.

^bWe exclude elective readmissions and trauma-related readmissions.

different categories of this disorder as identified by *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* codes.²⁹ These different categories are enumerated in Appendix A with respective *ICD-9-CM* codes. The conditions are grouped into broader categories and used in the multivariate models as follows: opioid-type dependence (reference category), combination of opioid-type drugs, opioid abuse, poisoning by opium, poisoning by opiate antagonists, and others. Table 1, which lists mean characteristics of our model variables, presents the distribution by different OUD diagnoses. Our sample is limited to those who were hospitalized with a principal diagnosis of OUD. The most common (45%) principal diagnosis was poisoning by opium (alkaloids), unspecified; heroin; methadone; and other opiates and related narcotics. The second most common (29%) principal diagnosis is opioid-type dependence (unspecified, continuous, episodic).

The 5 states are California, New York, Tennessee, Florida, and Missouri. The states were chosen to represent different geographic locations, sociodemographic characteristics, and rural/urban status. The HCUP database includes a robust and validated data on patient identifiers to calculate readmissions, as well as a broad set of variables including patient zip code of residence, de-identified linkage variables, race/ethnicity, severity score (All Patient Refined Diagnostic Related Groups [APR-DRGs]), and expected payer including those discharges in which there is not an expected payer. The total population in these 5 states represented 28.6% of US total population in 2014, with New York, Florida, and California accounting for one quarter of nation's total population.

The study uses multilevel logistic models, combining characteristics of patients, area of residence (small area/primary care service area or PCSA), and hospitals where they were treated. Primary care service areas are defined as groups of zip

codes where patients receive their primary care services from physician's offices.³⁰ To create the analytical files, discharge-specific data for each patient in the HCUP were combined with PCSA-level data by linking the patient's resident zip code available from HCUP-SID to PCSA data of Health Resources and Services Administration's (HRSA) Area Resource File by using the zip code—PCSA crosswalk file (HRSA). The file created as above provides the community-level information for each patient. In the next step, the above data set was linked to AHA's Annual Survey of Hospitals database to obtain characteristics of the hospitals where patients were initially admitted.

Using a multivariate framework and a logistic model approach, the study evaluates outcomes of these patients, controlling for covariates at the patient level including health status, PCSA, and hospital levels. Standard errors were adjusted for clustering at the PCSA level.

Outcome

The outcome of interest for this study is the patient's risk of 30-day all-cause hospital readmission, defined as the probability of a hospital readmission within 30 days of discharge from an index hospital admission of OUD as principal diagnosis. Approaches defining readmissions often use broad definitions, such as the one used by 3M³¹ for potentially preventable readmissions (clinically related to a prior admission) or the one Centers for Medicare & Medicaid Services (CMS) is using for specific admission types (using all-cause readmissions). We follow the CMS' approach by focusing on all-cause 30-day readmission following a specific index admission type (ie, principal diagnosis of OUD).³² A patient can be counted multiple times within the January to November observation period³³; however, only one readmission is counted within the 30-day period of each admission. In addition, a hospital stay may be a readmission for a prior stay and the index admission for a subsequent readmission. Certain categories of readmissions are excluded from our study sample, including pregnancy-related readmissions, trauma-related readmissions (using the clinical classification code categories ≤ 236 and ≥ 225),³⁴ and elective readmissions (using readmission type). These exclusions are necessary to focus only on unplanned and potentially avoidable readmissions in this study.

Independent Variables

The independent variables consist of discharge-level, PCSA-level, and hospital-level factors as found on the discharge record of the index admission. The following independent variables were considered in the regression model, consistent with the conceptual framework described above, as well as those reported in previous research. We categorize them as explanatory variables and covariates. Explanatory variables are the independent variables we are primarily interested in based on our research hypotheses. Covariates are those independent variables that we adjust our estimates for so as to get an independent measure of association of explanatory variables with outcome.

Explanatory variables. Our primary interest is to determine the role of sociodemographic characteristics of patients with OUD and the contextual characteristics of the community they come from at index admission. The sociodemographic characteristics of patients are represented by their predisposing (age, sex, race/ethnicity) and enabling characteristics (primary expected payer, household income) at the index admission. These factors are perceived to vary across vulnerable population groups. Age is grouped into the following categories: 18 to 34 (reference), 35 to 44, 45 to 64, 65 to 74, 75 to 84, and 85+ years, while race is grouped into 4 categories: non-Hispanic white (reference), non-Hispanic black or African American, Hispanics, and other races (includes Asian or Pacific Islander, Native Americans, and others). Expected payer is grouped in to Medicare, Medicaid, private payer (reference), other payers, and self-pay/no charge. Household income is measured at the zip code quartile levels of patient's resident area.

Among sociodemographic characteristics of the community patients come from, an important measure is whether they came from a rural or an urban location. Urban–rural status of the patient was indicated by a variable called urban–rural commuting area, available from HCUP-SID and grouped into 4 categories: metropolitan, micropolitan, small town, and rural. We also focus on community resources, namely, supply and access to PCPs measured at the PCSA level, to examine the extent to which increased access to primary care is associated with lower readmissions following an OUD-related hospitalization. We measure primary care access by 2 variables: (1) primary care provider density, measured at the PCSA level as the number of clinically active PCPs per 100 000 population, and (2) percentage of beneficiaries residing in the PCSA who had at least 1 primary care visit (the latter is based on Medicare part B and outpatient file).

Covariates. We use several covariates in our regression model at patient, hospital, and community levels, all information being related to the index admission. Some of these factors represent patient needs, including patient's health status and disease severity. Patient disease severity score is indicated by 3M's APR-DRGs severity index in the HCUP database and reported in 4 categories: minor, moderate, major, extreme.³⁵ An APR-DRG weight variable is also computed as an aggregate average length of stay (to approximate case-mix intensity) by APR-DRGs in 5 states. A variable on admission type is also added, with urgent and emergency admissions indicating higher severity. We include a categorical variable showing the number of chronic conditions on index admissions, grouping them into 3 categories: 0 to 1, 2 to 3, and 4 and above. We also include an indirect measure of disease severity: average length of stay of the patient at the hospital. In addition, we control for discrete OUD categories (described above). Hospital covariates as reported and derived from the AHA files include hospital ownership status (for-profit, not-for-profit), safety-net status (defined as hospitals with percentage shares of Medicaid and self-pay patients in the top quartile),³⁶ teaching status, and hospital bed size. Hospital bed size is measured in 3 categories:

small (reference), medium, and large. Other community characteristic includes population density measured as thousands of total population per square mile land area at the PCSA level.

The analysis is conducted using STATA version 14. Because of the small sample size, only aggregate-level analysis (pooled states) is conducted.

Patient profiles in our sample. The study first presents patient profiles by characteristics of patients and areas of residence in Table 1. A total of 25,561 discharges in 5 US states with a principal diagnosis of OUD was included in the multivariate analysis.

Multivariate Results

Findings on Explanatory Variables

Multivariate results on patient sociodemographic factors indicate that the risk of readmission increased with age. Relative to the 18 to 34 age-group, 35- to 44-, 45- to 64-, 65- to 74-, and 75- to 84-year-olds were, respectively, 19%, 39%, 40%, and 56% more likely ($P \leq .01$) to have a readmission. Although men were more likely to have a readmission than women, readmission risks did not vary by racial/ethnic groups. Controlling for age and severity of illness, Medicare patients were twice as likely to be readmitted (odds ratio [OR] = 2.03, $P < .01$) as those covered by private payers, while Medicaid patients were also 71% (OR = 1.71, $P < .01$) more likely. Self-pay patients or patients with other coverage were not significantly different from those with private coverage. Patient's readmission risks did not vary by median household income measured at the zip code quartile levels (Table 2).

Among sociodemographic factors in the community, higher PCP density in the PCSA was associated with lower risks of readmissions. Compared to the areas with 0 to 4 PCPs per 100,000 population, patients living in the PCSAs with 5 to 14 PCPs per 100,000 population were 61% less likely to have a readmission. Those living in areas with 15 to 57 and 58 and over PCPs per 100,000 population were also less likely to have a readmission than those in 0 to 4 PCPs/100,000 areas (52% and 51%, respectively). We also found that patients living in rural areas were significantly less likely (OR = 0.63, $P < .01$) to be readmitted than metropolitan patients.

Findings on Covariates

Other factors in the multivariate model, used as covariates, also show interesting associations with readmission rates. Having multiple chronic conditions significantly increased the risk of readmission, with patients with OUD having 4 and more chronic conditions 51% more likely (OR = 1.51, $P < .01$) than those with 0 to 1 chronic condition. Likewise, more severe cases were more likely to be readmitted. Readmission rate did not vary by types of opioid diagnosis. None of the hospital characteristics, such as bed size, safety net status, teaching status, or ownership status, was significantly associated with readmission rates.

Table 2. Logistic Regression Model Results for 5 States: Odds Ratios of All-Cause 30-Day Readmission (Versus No Readmission), 2014.^{a,b}

Patient Characteristics	N = 25,561
Female	0.90 (0.82-0.99) ^c
Age group (reference: age 18-34)	
35-44	1.19 (1.07-1.331) ^c
45-64	1.39 (1.21-1.60) ^c
65-74	1.40 (1.14-1.73) ^c
75-84	1.56 (1.17-2.06) ^c
85+	1.27 (0.82-1.96)
Race (reference: white)	
African American	0.99 (0.90-1.10)
Hispanic	1.04 (0.89-1.221)
Other race	1.00 (0.85-1.18)
# Chronic conditions (reference = 0-1)	
Chrn1 (2-3)	1.26 (1.00-1.57) ^c
Chrn2 (4+)	1.51 (1.19-1.91) ^c
Opioid diagnoses types (reference = opioid-type dependence)	
Combination of opioid-type drug	0.97 (0.84-1.13)
Opioid abuse	1.11 (0.80-1.52)
Poisoning by opium	0.94 (0.80-1.10)
Poisoning by opium antagonists	0.86 (0.58-1.28)
Expected payer (reference = private coverage)	
Medicare	2.02 (1.65-2.49) ^c
Medicaid	1.69 (1.44-1.99) ^c
Self-pay/no charge	1.15 (0.96-1.38)
Other pay	1.27 (0.95-1.71)
Average length of stay at the hospital (ALOS)	0.99 (0.98-0.99) ^d
APR-DRG weights	1.54 (1.40-1.70) ^c
APR-DRG severity of illness (reference: minor)	
Moderate	1.30 (1.16-1.47) ^c
Major	1.51 (1.30-1.74) ^c
Extreme	1.64 (1.38-1.945) ^c
Admission type (reference: elective and other)	
Emergency	1.12 (0.95-1.33)
Urgent	1.02 (0.86-1.19)
Admitting hospital characteristics	
Safety net (reference = non-safety net)	1.05 (0.96-1.15)
Teaching (reference = nonteaching)	1.10 (0.96-1.25)
For-profit ownership (reference = government)	1.03 (0.92-1.15)
Bed size (reference: small)	
Medium	0.85 (0.71-1.03)
Large	0.97 (0.83-1.14)
Community characteristics	
Population density	1.00 (1.00-1.00) ^c
Rural urban commuting area (reference: metropolitan)	
Micropolitan	1.03 (0.89-1.20)
Small town	0.86 (0.72-1.02)
Rural	0.63 (0.47-0.84) ^c
Median household income national quartile for patient zip code (reference: US\$0-39,999)	
US\$40,000-49,999	0.93 (0.84-1.04)
US\$50,000-65,999	0.97 (0.86-1.09)
US\$66,000 +	1.00 (0.88-1.14)
PCP/100,000 (ref: 0-4/100,000)	
5-14	0.38 (0.18-0.80) ^c
15-57	0.48 (0.28-0.82) ^c
58 and up	0.49 (0.28-0.84) ^c
PCSA with patients having at least 1 outpatient visit	0.99 (0.98-1.00)

Abbreviations: APR-DRG, All Patient Refined Diagnostic Related Groups; PCP, primary care physician; PCSA, primary care service area.

^aRounding errors are present. The data in the parenthesis represent confidence intervals for the respective odds ratios.

^bStandard error in the logistic regression model is adjusted for clustering within PCSAs of patient's residence.

^cEstimates are significant at $\alpha = .01$ level.

^dEstimates are significant at $\alpha = .05$ level.

Sensitivity Tests

Findings reported above are robust to sensitivity tests. We conducted several sensitivity tests, including additional variables, such as hospital mortality rates (to indicate hospital quality), with no change in findings. In addition, we added state fixed effects to account for state-specific factors, with no changes in findings. Additionally, our results were unaffected when we excluded patients who died in the hospital. We also included and tested the model including several unrelated patient comorbidities such as alcohol abuse, depression, drug abuse, and psychoses with no change in findings. These comorbidities were not consistently significant after severity and chronic condition adjustments were made. Some association between readmission risks and drug abuse comorbidity was, however, found (OR = 1.13, $P < .01$) among a larger sample, with opioid disorder either a principal or a major secondary diagnosis (among the first 4 secondary diagnoses of a patient).

Discussion

Readmissions occur because of a complex set of factors, some of which are patient-specific, some of which are attributable to hospital quality and contextual factors. Using this general framework, we assess the association of socioeconomic and demographic characteristics of patients with OUD and their community with readmissions rates and make some noteworthy observations.

The study indicates that, consistent with a general pattern, the risk of readmission following an OUD hospitalization also increases with age. Although the risk was highest in the 75 to 84 age-group, this age-group, however, accounted for only 2.33% of OUD admissions. Possible reasons include higher likelihood of readmissions among the elderly patients due to the prevalence of multiple chronic conditions and increased prescription drug use. The exception is the 85 years and older patients who faced similar risks as the 18- to 34-year-olds. One reason for 85+ patients facing lower risks of readmissions could be their postdischarge likelihood of mortality or factors such as higher resiliency.

As expected, both Medicare and Medicaid patients were found to be significantly more likely to be readmitted than those with a private coverage or with no coverage. Interestingly, however, self-pay patients and those with private coverage had equal risks of readmissions, which are lower than those on Medicare or Medicaid. One explanation could be that both elderly Medicare and low-income Medicaid patients are likely to have poorer health status and thus likely to have higher risks of readmissions. Although we controlled for patients' health status and age, some residual health status differences could likely remain. However, the findings also raise questions as to whether because of better financial coverage, the Medicare/Medicaid patients had the option to come back to the hospital for a readmission, while a second admission may be burdensome for self-pay patients or for those covered by private payers with a substantial cost-sharing requirement. This

observation is consistent with past research that provides evidence that lower readmission rates may not always be construed as a good outcome because it could result from a lack of insurance coverage and poor access to care,²⁵ with lower readmission rate among minorities who were self-pay compared to minorities with Medicare coverage. The issue in this context deserving further consideration is whether a person with private coverage admitted with opioid disorder had adequate coverage or as good a coverage as those admitted with a public coverage to have a second needed admission.

Another related finding in this context was that the patients in rural areas were less likely to be readmitted than urban patients. Average in-hospital death rates were the highest among rural patients (2.4%) compared to an overall average of 1.3% for our study sample. On the other hand, average readmission rates of rural area patients were the lowest (7%) compared to the overall average (12%). Previous studies have shown that distance is a deterrent to hospitalization for rural patients even when they are more severely ill, which may very well explain their reduced readmission rate and a higher in-hospital death rate. Although we did not find a statistically significant higher ($P > .05$) in-hospital death rates of rural than metropolitan patients, our findings suggest the possibility that lack of access to hospitals could prevent rural patients to receive the adequate treatment they needed.

Among other noteworthy findings, those related to primary care deserves further mention. Relative to areas with 0 to 4 physician density, higher PCP density was associated with reductions in risks of readmissions. Readmission rates were the lowest when PCP density was 5 to 14/100,000, thereafter declining more slowly as PCP density increased. Descriptive data in our sample show that PCSAs with 0 to 4 PCPs/100,000 had the highest readmission rates (16.5%) compared to an overall average of 12% across all areas. The association of higher PCP density with reduction in readmission rates for patients with OUD is consistent with studies showing post-discharge physician follow-up significantly reducing readmission risks among certain types of patients (eg, chronic obstructive pulmonary disease and heart failure).^{37,38} On the other hand, the decline in the rate of reduction in readmissions rates after a certain PCP density level was reached is also consistent with previous research^{17,27} which showed a positive association between PCP density and readmission risks, possibly due to better physician monitoring. A recent study shows high PCP density counties associated with lower risks of opioid overdose and lower risk of lacking in capacity to deliver medications.⁷ Although small, our study found higher number of primary care visits to be associated with fewer readmissions. The issue needs further investigation since primary care could play important role in care transitions and care coordination.

The study has several limitations, including our inability to measure the impact of postacute care transitions which is found to have a direct bearing on readmission outcome.²⁶ We also could not account for the patients who crossed state borders or who died after the first discharge. In addition, we only captured readmissions to community hospital (nonrehabilitation) and

could not capture information about specialty substance abuse treatment facilities. Restricting our sample to principal diagnosis of OUD and to only 5 states limits our sample size. However, the advantage of focusing on principal diagnosis is that it creates a more homogenous sample of observations. Although the 5 states we chose are not necessarily representative of the entire population, we include both highly populated states, such as California, New York, and Florida, and smaller states. Although we analyze data at the patient level, the patient visit information for outpatient care was not available and thus was replaced with such data at the PCSA level. In addition, the study could be updated with more recent data to highlight more recent trends.

Finally, consistent with CMS approach, we measure 30-day readmissions for all causes instead of those related to opioid use alone, latter being the focus of a few recent studies^{14,15} that evaluated the relationship between opioid treatment policies and receipt of inpatient drug detoxification and/or rehabilitation services and subsequent opioid-related readmission. Because we focus on risks of readmissions of patients with OUD for any cause, our multivariate models did not include the opioid-related treatment protocols in the hospitals as covariates, which will be relevant when both admissions and readmissions are OUD related. A recent study, however, found that although one quarter of opioid overdose patients have 90-day all-cause readmissions, opioid overdose readmission is relatively uncommon.³⁹

The study's strength lies in its multilevel framework, capturing patient's community factors at the small area level, admitting hospital characteristics, and including all patients with OUD both below and above age 65 years. Because of our interest in examining the role of selected patients and community characteristics in readmissions, looking at all-cause readmissions allows us to capture the common risk factors that drive different types of readmissions when patients are admitted with an OUD diagnosis at the index admission.

Conclusion

Using a multilevel conceptual framework of readmissions, we examine the association of 30-day all-cause readmissions with socioeconomic characteristics of patients admitted with OUD diagnoses and their community characteristics measured at the small area level. Controlling for health status, we found the self-pay patients or those covered by private payers were less likely to be readmitted than Medicare or Medicaid patients, a finding that needs further investigation as to whether it implies financial burden preventing the needed admission. Likewise, lower readmission risks among rural than urban patients could indicate lower access to care among rural patients. The study's finding of higher readmission rates in areas with the lowest primary care density (0-4/100,000) highlights the role of primary care in care transitions, particularly in areas with acute PCP scarcity. The study calls for further policy interventions targeting the population subgroups with OUD, particularly the self-pay, the underinsured, rural patients, or patients living in

areas with PCP shortage. Future studies should use more current data to examine the role of community factors, such as primary care access and rural location, and socioeconomic conditions, such as income and payer categories, in assessing readmission risks among patients with OUDs.

Appendix A

International Classification of Diseases, Ninth Revision, Clinical Modification codes prior to October 1, 2015:

- 304.00 to 304.02: Opioid type dependence (unspecified; continuous; episodic)
- 304.70 to 304.72: Combinations of opioid type drug with any other drug dependence (unspecified, continuous, episodic)
- 305.50 to 305.52: Opioid abuse (unspecified, continuous, episodic)
- 965.00 to 965.02; 965.09: Poisoning by opium (alkaloids), unspecified; heroin; methadone; other opiates and related narcotics
- 970.1: Poisoning by opiate antagonists

Authors' Note

The views expressed in this paper are those of the author. No official endorsement by any agency of the federal government is intended or should be inferred.

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