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# Comparison of 30-day readmission and emergency department revisit rates among homeless patients at teaching versus non-teaching hospitals

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ABSTRACT

Providing quality healthcare for homeless patients is a major public health challenge, and some hospitals may be better at treating homeless patients than others. However, whether the quality of care that homeless patients receive differs by the teaching status of hospitals remains unclear. Using statewide databases that include all hospital admissions and emergency department (ED) visits in four states (Florida, Massachusetts, Maryland, and New York) in 2014, we compared 30-day readmission and ED revisit rates for homeless and non-homeless patients discharged from teaching hospitals versus non-teaching hospitals, after adjusting for patient and hospital characteristics. Among 3,438,538 patients (median age [IQR]: 63 [49–77] years) analyzed, 132,025 (4%) were homeless patients. Overall, homeless patients had a higher readmission rate (28.3% vs. 17.7%; average marginal effects [AME], 10.5%; 95% confidence interval [CI], 8.2%–12.9%; $p < 0.001$) and a higher ED revisit rate (37.6% vs. 23.9%; AME, 13.7%; 95%CI, 10.9%–16.6%; $p < 0.001$) than non-homeless patients. Patients from teaching hospitals had similar readmission rate (18.2% vs. 18.3%; AME, −0.1%; 95%CI, −0.8%–0.5%; $p = 0.69$) and slightly lower ED revisit rate than those from non-teaching hospitals (24.1% vs. 25.2%; AME, −1.1%; 95%CI, −1.9% to −0.3%; $p < 0.01$). When we focus on joint effects of homelessness and hospital teaching status, we found that homeless patients treated at teaching hospitals had lower rates of 30-day readmission (AME, −5.8%; 95%CI, −9.7% to −1.8%; $p < 0.01$) and ED revisit (AME, −9.3%; 95%CI, −13.1% to −5.5%; $p < 0.001$) compared to those treated at non-teaching hospitals. For non-homeless patients, in contrast, we found no evidence that rates of hospital readmission (AME, 0%, 95%CI, −0.1%–0.1%; $p = 0.94$) or ED revisit (AME, −0.9%; 95%CI, −1.7% to −0.1%; $p = 0.02$) differ between teaching and non-teaching hospitals. These findings suggest the healthcare settings in which homeless patients receive care have important implications for their patient outcomes.

## 1. Introduction

The number of homeless individuals in the United States (US) has nearly doubled over the past three decades (Henry et al., 2018; The U.S. Department of Housing and Urban Development, 1984). An estimated 3.5 million Americans experience homelessness annually, and 600,000 individuals are homeless on any given night (Henry et al., 2018; United States Interagency Council on Homelessness, 2015). Homeless individuals struggle with higher rates of medical and psychiatric diseases, including poorly controlled hypertension and diabetes, liver diseases,

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infectious diseases, mental illness, substance use disorder, and premature mortality (Fazel et al., 2014; Wadhera et al., 2019a). They are also more likely to encounter socioeconomic barriers to accessing medical care, including the lack of social support, limited financial resources, and poor health literacy. However, despite growing attention to patients' social needs and efforts to link medical and social services organizations (Center for Medicare and Medicaid Services, 2017), the U.S. health system remains poorly equipped to effectively care for homeless individuals, and compared to patients with stable housing, homeless patients are more likely to revisit the emergency department (ED) and be readmitted to the hospital after hospital discharge (Bharel et al., 2013; Buck et al., 2012; Kushel et al., 2002; Saab et al., 2016). Many factors contribute to high readmission and ED revisit rates of homeless patients, including suboptimal in-hospital care quality, poor transitional care (e.g., care coordination and discharge), and lack of access to outpatient providers (Doran et al., 2013; Hansen et al., 2011; Sadowski et al., 2009).

Recognizing the health and financial burden of frequent hospital admissions, policymakers have introduced programs, such as the Hospital Readmissions Reduction Program (HRRP), aimed at encouraging hospitals to improve discharge planning and care coordination (Centers for Medicare and Medicaid Services, 2019). Some state-specific policies have also been introduced to improve care for patients with unstable housing, such as California's recent legislation (SB 1152), requiring hospitals to provide written plans for care coordination and social service agency referral to homeless patients at the time of discharge ("Bill Text - SB-1152 Hospital patient discharge process: homeless patients.," 2018). Little is known, however, about which healthcare organizations attain fewer hospital revisits for the homeless population and what factors contribute to their ability to do so.

Teaching hospitals have historically played an important role in caring for underserved populations, driven by their educational and social missions. Nevertheless, in the U.S. healthcare market, which has been witnessing the increasingly high cost of healthcare and a shift from volume-to value-based reimbursement over the past couple of decades (Chee et al., 2016), teaching hospitals are considered as expensive than non-teaching hospitals (Mechanic et al., 1998; White et al., 2014), and insurers and policymakers are trying to keep patients from going to high-cost hospitals (Robinson and MacPherson, 2012). However, recent research has found that higher inpatient cost of care at teaching hospitals was offset by lower post-acute care costs (Burke et al., 2019). More importantly, patients experienced lower mortality at teaching hospitals than at non-teaching hospitals (Burke et al., 2018, 2017). It remains unclear, however, whether teaching hospitals perform better than non-teaching hospitals for the care of vulnerable and underserved patient populations such as homeless patients.

Therefore, in this study, we examined the association between hospital teaching status and rates of readmission or emergency department (ED) revisits for homeless patients and non-homeless patients, using statewide databases that include all hospital admissions and ED visits in the U.S. We hypothesized that homeless patients would have lower rates of readmissions or ED revisits when treated at teaching hospitals compared to non-teaching hospitals due to higher-quality discharge planning and care coordination at teaching hospitals. We also investigated if these associations varied by whether a patient was treated for medical versus surgical conditions, because the reasons for readmissions and ED revisits might differ between medical and surgical conditions, e.g., hospital revisits for medical conditions may be primarily due to poor discharge planning and care coordination, whereas surgical patients may be more likely to return to hospitals as a result of complications (Kassin et al., 2012; Tsai et al., 2013).

## 2. Methods

### 2.1. Data source and study sample

We linked two databases: (1) the 2014 State Inpatient Database (SID) and the State Emergency Department Databases (SEDD) from four states (Florida, Maryland, Massachusetts, and New York) (The Healthcare Cost and Utilization Project, 2020, 2019), and (2) the 2016 American Hospital Association (AHA) Annual Survey database. The SID/SEDD data were collected by the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality (AHRQ). The SID includes all inpatient discharge records from acute care hospitals in a given state, regardless of the source of hospital admission and insurance status. The SEDD includes all discharge records on ED visits at hospital-affiliated EDs that did not result in hospital admission. These 4 states were selected due to their geographic and socio-demographic diversity as well as the availability of the homeless indicator and unique patient linkage number (only 6 states [four states included in our analysis plus Utah and Wisconsin] included both the homeless indicator and unique patient identifier, and Utah and Wisconsin were not included in our analyses because our internal investigation identified a severe underreporting of the homeless indicator) (Yamamoto et al., 2019). These 4 states representing approximately 30% of the entire homeless population in the U.S. (Henry et al., 2018)).

The AHA Annual Survey database includes information on hospital characteristics including teaching status, profit status, Rural-Urban Commuting Area (RUCA) classification, hospital size, and the presence of a medical or cardiac intensive care unit (ICU) (American Hospital Association, 2019).

We included all adults aged 18 years or older who were admitted to non-federal acute care hospitals in 2014 and were not transferred to another acute care facility, and examined their rates of readmission and ED revisit after hospital discharge. Discharges that occurred in December 2014 in Massachusetts and New York were excluded to ensure a full 30 days of follow-up of these two states. For Maryland and Florida, we excluded discharges occurring in the last quarter because only discharge quarter information was available. Of the 4,519,374 hospitalizations in our initial sample, we excluded 193,877 hospitalizations (4.3%) of patients who died during their hospitalization or those discharged against medical advice (because hospitals may have limited control over the quality of discharge care patients receive in such cases). We also excluded 516,544 hospitalizations (11.4%) with a primary discharge diagnosis related to childbirth. Finally, we excluded 370,415 (8.2%) hospitalizations with missing data on the outcome or explanatory variables. Our final analytic sample consisted of 3,438,538 (76.1%) hospital discharges.

Independent Variables of Interest.

### 2.2. Homelessness

The primary exposure variables of interest were (1) homeless status (homeless vs. non-homeless), and (2) hospital teaching status (teaching vs. non-teaching). The SID/SEDD provides the indicator variable for homeless status directly reported by hospitals at discharge, which has been used in previous AHRQ reports (Karaca et al., 2013; Sun et al., 2017) and in other studies (Wadhera et al., 2019a, 2019b; Yamamoto et al., 2019). Since identifying homeless individuals based on information collected at hospital discharge may lead to under-reporting of homeless status (as some homeless individuals may be recorded as "housed" if they were living in a shelter or an acquaintance's house), we defined homeless individuals as those who were homeless during any encounter at the hospital or ED within a given year (including both individuals living on the street [primary homeless] and those moving between temporary shelters, friends' residences, and emergency accommodation [secondary homeless]).

### 2.3. Teaching hospitals

Hospitals that had the membership in the Council of Teaching Hospitals and Health Systems of the Association of American Medical Colleges or affiliated with medical universities (include both major and minor teaching hospitals) were considered as teaching hospitals, identified using the AHA Annual Survey (Ayanian and Weissman, 2002; Brennan et al., 1991).

### 2.4. Outcome variables

Our outcomes of interest were (1) all-cause readmission, captured according to methodology recommended by the HCUP (Barrett et al., 2011), and (2) all-cause ED revisit within 30 days after hospital discharge, as prior studies have suggested that examining readmissions alone may not fully capture acute care utilization after an index hospitalization (Wadhera et al., 2019).

### 2.5. Control variables

We adjusted for patient characteristics, hospital characteristics, and state and quarter fixed effects. Patient characteristics include the primary diagnosis (defined using Medicare Severity-Diagnosis Related Group [MS-DRG] codes), age (18–29, 30–39, 40–49, 50–59, 60–69, 70–79, and 80 years or older), sex, race and ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, and others), primary payer (Medicare, Medicaid, private insurance, self-pay, and others), and indicator variables for 29 comorbidities included in Elixhauser comorbidity index. The Elixhauser comorbidity index is a method for measuring patient comorbidity related to an increased risk of in-hospital deaths or 30-day readmissions based on ICD diagnosis codes (Elixhauser et al., 1998). It consists of 29 coexisting conditions (e.g., diabetes, hypertension, depression, alcohol abuse, and drug abuse) to assess the risk of readmissions (Moore et al., 2017). Hospital characteristics include the profit status (for-profit, non-profit, and public), RUCA (urban, suburban, large rural, and small rural), hospital size (large [400+ beds], medium [100–399 beds], and small [1–99 beds]), and the presence a medical or cardiac ICU. State and quarter fixed effects account for both measured and unmeasured (time-invariant) characteristics of states and quarter (time trend), allowing us to effectively compare patient outcomes within the same state and quarter.

### 2.6. Statistical analysis

First, we described the patient characteristics by homeless status and the hospital characteristics by hospital teaching status.

Second, we compared patient outcomes between teaching versus non-teaching hospitals, and between the homeless and non-homeless patient populations, separately (without using the interaction term between hospitals' teaching status and patients' homeless status). In doing so, we constructed the following logistic regression model:

$$Logit(OUTCOME_{ij}) = \beta_1 TEACHING_j + \beta_2 HOMELESS_{ij} + \gamma X_j + \delta Z_{ij}$$

where $OUTCOME_{ij}$ denotes whether patient $i$ treated at hospital $j$ experienced readmissions/ED revisits within 30 days of hospital discharge; $TEACHING_j$ represents the teaching status of hospital $j$; $HOMELESS_{ij}$ denotes whether a patient $i$ treated at hospital $j$ was homeless or not; and $X_i$ and $Z_{ij}$ are control variables for hospitals and patients, respectively. We constructed two sets of multivariable logistic regression models. Model 1 adjusted for patient characteristics and state and quarter fixed effects (Wooldridge, 2010). Model 2 adjusted for all variables included in Model 1 plus hospital structural characteristics (Brand et al., 2012; Brennan et al., 1991). Standard errors were clustered at the hospital-level to account for a potential correlation of patients treated at the same hospital (Wooldridge, 2010). For each hospital discharge, we calculated predicted rates of patient readmission and ED revisit with either of homeless status or hospital teaching status fixed at each category and then averaged over the distribution of covariates in our sample (Williams, 2012). To improve interpretability of findings, for our main analyses, we calculated average marginal effects (AME) of either of homeless status and hospital teaching status (instead of odds ratios), which represents the differences in the predicted rates of patient readmissions and ED revisits.

Third, using the same regression models, we examined how the differences in rates of readmissions and ED revisits between teaching versus non-teaching hospitals varied by the homeless status of patients, by including the interaction term between the homeless status and hospital teaching status in our regression models as follows:

$$Logit(OUTCOME_{ij}) = \beta_1 TEACHING_j + \beta_2 HOMELESS_{ij} + \beta_3 TEACHING_j \times HOMELESS_{ij} + \gamma X_j + \delta Z_{ij}$$

Using this regression model, we calculated and reported (i) AME of hospital teaching status (teaching hospitals vs. non-teaching hospitals) separately for the homeless patients and non-homeless patients, and (ii) the difference-in-differences (differences in the AME between the homeless and non-homeless patients) to test the interaction between homeless status and teaching status. To improve interpretability, we showed the predicted risk-adjusted rates of 30-day readmission and ED revisit for each of four patient groups (homeless patients at teaching hospitals, homeless patients at non-teaching hospitals, non-homeless patients at teaching hospitals, and non-homeless patients at non-teaching hospitals) using marginal standardization (Williams, 2012). To account for multiple comparisons, we considered a P-value $< 0.0125$ to be statistically significant. We used a similar approach for the analyses of ED revisits after hospital discharge.

Finally, we conducted a stratified analysis by medical and surgical admissions, because the reasons for high likelihood of readmissions and ED revisits may differ between medical and surgical conditions (Tsai et al., 2013). The medical conditions consist of all the conditions assigned to the Major Diagnostic Category (MDC) codes (01–25) in the list of the MS-DRG version 28, and the surgical conditions consist of all the procedures assigned to MDC codes (01–25) in the list of MS-DRG version 28).

### 2.7. Secondary analyses

We conducted a series of secondary analyses. First, we conducted a sensitivity analysis, focusing on the indicator variable for 30-day hospital revisits (readmissions or ED revisits), which had the highest missingness among all the variables included in our regression analyses (2.5%). To account for the missing data, we constructed the multivariable logistic regression models weighted by the inverse of the predicted probability of observing the indicator variable for 30-day hospital revisits (see Appendix for details). Second, we defined homelessness at the point of hospital discharge and ED visit rather than at any time within a given year and repeated the analyses. Third, to examine whether the observed relationships depend on the definition of hospital teaching status, we used an alternative definition of teaching hospitals based on intern/resident to bed ratio (IRB) as continuous variables, indicating teaching status and repeated the analyses(Burke et al., 2018, 2017). Fourth, to test the hypothesis that teaching hospitals may provide better care for patients with complex conditions, we conducted stratified analysis by patients' severity of illness, using tertiles of predicted annual in-hospital mortality in 2014 (see Appendix for details). Fifth, we examined whether our findings vary by the primary condition/procedure of hospitalization. We selected five medical conditions (four conditions targeted in the HRRP, heart failure [CCS single-level diagnosis code: 127], pneumonia [108], chronic obstructive pulmonary disease [122], and acute myocardial infarction [100](Centers for Medicare and Medicaid Services, 2019), plus mental illness [650–663 and 670], which are commonly observed among the homeless population(Karaca et al., 2013)) and four common high-risk surgical procedures (Burke et al., 2017; Centers for Medicare and Medicaid Services, 2019) (knee arthroplasty [CCS single-level procedure code: 152], hip replacement [153], colorectal resection [78], and coronary artery bypass grafting [44]). Finally, to test whether our findings were due to random chance because of the extremely large sample size, we conducted a falsification test. In particular, we investigated whether patient outcomes differ between teaching and non-teaching hospitals for both homeless and non-homeless patients, using a "placebo" outcome. The placebo outcome we used was a variable called "DaysToEvent," which is a continuous number randomly assigned to each patient with the aim of encrypting actual date when patients received care (to avoid re-identification of individuals based on the date when they received care) (Agency for Healthcare Research and Quality, 2008).

All analyses were conducted using Stata version 15 (College Station, TX; StataCorp LLC.).

## 3. Results

### 3.1. Patient characteristics by homeless status

Of 3,438,538 patients in our analytic sample, 132,025 (3.8%) were identified as homeless. Compared to non-homeless patients, homeless patients were younger; more likely to be male; from a racial/ethnic minority group; and covered by Medicaid (Table 1).

### 3.2. Hospital characteristics by teaching status

Compared to non-teaching hospitals, teaching hospitals were larger; more likely to be non-profit; located in urban areas; and have a medical or cardiac ICU (Table 2).

### 3.3. Readmissions and ED revisits by homeless status and hospital teaching status

Overall, homeless patients had higher rates of 30-day readmissions (adjusted readmission rate, 27.4% vs. 17.8%; AME, 9.6%; 95% confidence interval [CI], 7.0%–12.3%; P < 0.001) and ED visits (adjusted ED revisit rate, 36.8% vs. 23.9%; AME, 12.9%; 95% CI, 9.7%–16.1%; P < 0.001) after hospital discharge compared to non-homeless patients, after adjusting for the patient characteristics and state and quarter fixed effects (Model 1) (Table 3). For teaching status (an analysis including both homeless and non-homeless patients), we found a slightly higher readmission rate (adjusted readmission rate, 18.6% vs. 17.5%; AME, 1.1%; 95% CI, 0.5%–1.7%; P < 0.001) and a slightly lower ED revisit rate (adjusted ED revisit rate, 24.2% vs. 25.0%; AME, −0.8%; 95% CI, −1.4% to −0.2%; P < 0.01) when treated at teaching hospitals compared to non-teaching hospitals. These associations did not change qualitatively after additional adjustment for hospital characteristics in Model 2, except for readmission rates by hospital teaching status, where the difference in readmission rates between teaching hospitals and non-teaching hospitals were statistically insignificant. As for other hospital characteristics, larger hospitals with cardiac ICU had higher readmission rates, whereas public hospitals in rural areas tended to show lower readmission rates (eTable 1). The teaching status of hospitals was the only hospital characteristic that was associated with the rate of ED revisits (eTable 2).

**Table 1**
Patient characteristics by homeless status.

| | | Homeless | Non-homeless | P-value |
|---|---|---|---|---|
| No. of discharges | | 132,025 | 3,306,513 | |
| Age, mean (SD), y | | 51.3 (17.2) | 62.6 (18.6) | <0.001 |
| Female, % | | 39.5 | 53.0 | <0.001 |
| Race/ethnicity, % | Non-Hispanic White | 30.3 | 67.3 | |
| | Non-Hispanic Black | 33.0 | 16.2 | |
| | Hispanic | 22.5 | 10.6 | |
| | Others | 14.3 | 5.9 | <0.001 |
| Primary payer, % | Medicare | 30.2 | 55.7 | |
| | Medicaid | 57.1 | 14.2 | |
| | Private | 3.9 | 22.6 | |
| | Self-pay | 5.7 | 3.8 | |
| | Others | 3.1 | 3.7 | <0.001 |
| Comorbidities, % | Diabetes | 25.8 | 28.0 | <0.001 |
| | Hypertension | 46.4 | 60.9 | <0.001 |
| | Renal failure | 9.6 | 15.8 | <0.001 |
| | Chronic pulmonary disease | 23.1 | 25.8 | <0.001 |
| | Depression | 18.9 | 16.8 | <0.001 |
| | Obesity | 10.7 | 14.6 | <0.001 |
| | Alcohol abuse | 25.8 | 7.3 | <0.001 |
| | Drug abuse | 26.3 | 6.7 | <0.001 |

SD: Standard deviation.
P-values were calculated using Rank-sum test for continuous variables and chi-squares test for categorical variables.

**Table 2**
Hospital characteristics by teaching status.

| | | Teaching hospitals | Non-teaching hospitals | P-value |
|---|---|---|---|---|
| No. of hospitals | | 200 | 270 | |
| Profit status, % | For-profit | 9.5 | 38.5 | |
| | Non-profit | 78.0 | 55.2 | |
| | Public | 12.5 | 6.3 | <0.001 |
| RUCA, % | Urban | 97.5 | 70.0 | |
| | Suburban | 1.0 | 8.9 | |
| | Large rural town | 1.0 | 13.3 | |
| | Small rural town | 0.5 | 7.8 | <0.001 |
| Hospital size, % | Large (400+ beds) | 41.5 | 3.3 | |
| | Medium (100–399 beds) | 49.0 | 61.5 | |
| | Small (−99 beds) | 9.5 | 35.2 | <0.001 |
| Medical ICU, % | | 79.5 | 57.8 | <0.001 |
| Cardiac ICU, % | | 55.0 | 25.6 | <0.001 |
| State, % | New York | 40.0 | 26.3 | |
| | Maryland | 10.5 | 8.5 | |
| | Massachusetts | 21.0 | 5.9 | |
| | Florida | 28.5 | 59.3 | <0.001 |

RUCA: Rural-Urban Commuting Area. ICU: Intensive care units.
P-values were calculated using the chi-squares test.

### 3.4. Teaching vs. non-teaching hospitals for homeless patients

We found that homeless patients treated at teaching hospitals had lower rates of readmissions (AME, −5.4%; 95%CI, −9.6% to −1.3%; p = 0.01) and ED revisits (AME, −9.9%; 95%CI, −14.0% to −5.8%; p < 0.001) compared to homeless patients cared for at non-teaching hospitals, after adjusting for patient characteristics and state and quarter fixed effects (Table 4 and eTable 3). Additional adjustment for hospital characteristics did not affect our findings: homeless patients' readmission (AME, −5.8%; 95%CI, −9.7% to −1.8%; p < 0.01) and ED revisit rates (AME, −9.3%; 95%CI, −13.1% to −5.5%; p < 0.001) continued to be lower at teaching hospitals than non-teaching hospitals (Table 4). The predicted risk-adjusted rates of 30-day readmission for homeless patients (Model 2) were 27.5% when treated at teaching hospitals vs. 32.6% when treated at non-teaching hospitals, and the predicted risk-adjusted rates of 30-day ED revisit were 36.1% vs. 45.0% (Fig. 1 and eTable 3).

### 3.5. Teaching vs. non-teaching hospitals for non-homeless patients

For non-homeless patients, patients treated at teaching hospitals had

**Table 3**
Risk-adjusted rates of 30-day readmission and emergency department revisit after hospital discharge, by homeless status and hospital teaching status.

| | | Model 1 | | | Model 2 | | |
|---|---|---|---|---|---|---|---|
| | No. of patients | Adjusted rate, % (95% CI) | Average marginal effect, % (95% CI) | P value | Adjusted rate, % (95% CI) | Average marginal effect, % (95% CI) | P value |
| Readmission Rate | | | | | | | |
| Homeless status | | | | | | | |
| Homeless | 132,025 | 27.4 (17.4–30.1) | 9.6 (7.0–12.3) | <0.001 | 28.3 (25.9–30.6) | 10.5 (8.2, 12.9) | <0.001 |
| Non-homeless | 3,306,513 | 17.8 (17.5–18.1) | Reference | | 17.7 (17.5, 18.0) | Reference | |
| Teaching status | | | | | | | |
| Teaching hospitals | 2,173,065 | 18.6 (18.1–19.1) | 1.1 (0.5–1.7) | <0.001 | 18.2 (17.8–18.6) | −0.1 (−0.8 to 0.5) | 0.69 |
| Non-teaching hospitals | 1,265,473 | 17.5 (17.1–17.9) | Reference | | 18.3 (17.8–18.8) | Reference | |
| Emergency Department Revisit Rate | | | | | | | |
| Homeless status | | | | | | | |
| Homeless | 132,025 | 36.8 (33.6–40.0) | 12.9 (9.7–16.1) | <0.001 | 37.6 (34.8–40.5) | 13.7 (10.9–16.6) | <0.001 |
| Non-homeless | 3,306,513 | 23.9 (23.6–24.2) | Reference | | 23.9 (23.6–24.2) | Reference | |
| Teaching status | | | | | | | |
| Teaching hospitals | 2,173,065 | 24.2 (23.8–24.6) | −0.8 (−1.4 to −0.2) | <0.01 | 24.1 (23.7–24.5) | −1.1 (−1.9 to −0.3) | <0.01 |
| Non-teaching hospitals | 1,265,473 | 25.0 (24.5–25.4) | Reference | | 25.2 (24.6–25.8) | Reference | |

CI: confidence interval. We used multivariable logistic regression models. Standard errors were clustered at the hospital level to account for the potential correlation of patients treated at the same hospital. Adjusted rates were calculated using marginal standardization for each model. Average marginal effects of each exposure on all-cause 30-day readmissions and emergency department visits are shown. Model 1 adjusted for the quarter and state indicator variables and patient characteristics, including the primary diagnosis at index admission, age, sex, race/ethnicity, primary payers, and comorbidities. Model 2 adjusted for all variables included in Model 1 plus hospital characteristics, including profit status, Rural-Urban Commuting Area classification, hospital size, and the presence of medical/cardiac intensive care units.

**Table 4**
Average marginal effects on the rates of 30-day readmission and emergency department revisit after hospital discharge for teaching hospitals compared with non-teaching hospitals, by homeless status.

| | No. of patients | Homeless status | | | | Difference in differences | P values |
|---|---|---|---|---|---|---|---|
| | | Homeless | | Non-homeless | | | |
| | | Average marginal effect, % (95% CI) | P value | Average marginal effect, % (95% CI) | P value | | |
| Readmission | | | | | | | |
| Model 1 | 3,438,538 | −5.4 (−9.6 to −1.3) | 0.01 | 1.2 (0.6–1.8) | <0.001 | −6.6 (−10.7 to −2.6) | <0.01 |
| Model 2 | 3,438,538 | −5.8 (−9.7 to −1.8) | <0.01 | 0 (−0.1 to 0.1) | 0.94 | −5.8 (−9.6 to −1.9) | <0.01 |
| Emergency department revisit | | | | | | | |
| Model 1 | 3,438,538 | −9.9 (−14.0 to −5.8) | <0.001 | −0.7 (−1.2 to −0.1) | 0.03 | −9.2 (−13.3 to −5.2) | <0.001 |
| Model 2 | 3,438,538 | −9.3 (−13.1 to −5.5) | <0.001 | −0.9 (−1.7 to −0.1) | 0.02 | −8.4 (−12.1 to −4.6) | <0.001 |

CI: confidence interval. Average marginal effects for teaching hospitals compared to non-teaching hospitals are shown with 95% CIs. Model 1 adjusted for the quarter and state indicator variables and patient characteristics, including the primary diagnosis at index admission, age, sex, race/ethnicity, primary payers, and comorbidities. Model 2 adjusted for all variables included in Model 1 plus hospital characteristics, including profit status, Rural-Urban Commuting Area classification, hospital size, and the presence of medical/cardiac intensive care units.

slightly higher rates of 30-day readmissions (AME, 1.2%; 95%CI, 0.6%–1.8%; $p < 0.001$) and similar rates of ED revisits (AME, −0.7%; 95%CI, −1.2% to −0.1%; $p = 0.03$) than non-homeless patients discharged from non-teaching hospitals, after adjusting for patient characteristics and state and quarter fixed effects. When we additionally adjusted for hospital characteristics, we found no differences in readmission rates (AME, 0%; 95%CI, −0.1%–0.1%; $p = 0.94$) and ED revisit rates (AME, −0.9%; 95%CI, −1.7% to −0.1%; $p = 0.02$) between teaching and non-teaching hospitals. The predicted risk-adjusted rates of 30-day readmission for non-homeless patients (Model 2) were 17.7% when treated at teaching hospitals vs. 17.8% when treated at non-teaching hospitals, and the predicted risk-adjusted rates of 30-day ED revisit were 23.6% vs. 24.5% (Fig. 1 and eTable 3).

### 3.6. Interaction between homeless status and teaching status

The formal test of interaction between homeless status and teaching status showed statistically significant interaction for both readmissions (p-for-interaction<0.01) and ED revisits (p-for-interaction<0.001) using Model 2, indicating that the associations between homelessness and patient outcomes vary by teaching status of hospitals (Table 4).

### 3.7. Stratified analysis: medical vs. surgical conditions

Our stratified analysis showed that homeless patients had lower readmission rates at teaching hospitals for medical conditions (AME, −5.7%; 95%CI, −10.0% to −1.3%; $p = 0.01$), but not for surgical conditions (AME, −0.3%; 95%CI, −3.7%–3.1%; $p = 0.85$), after adjusting for patient characteristics and state and quarter fixed effects (Table 5). Homeless patients had lower rates of ED revisits when treated at teaching hospitals for both medical conditions (AME, −9.7%; 95%CI, −13.9% to −5.4%; $p < 0.001$) and surgical conditions (AME, −7.7%; 95%CI, −11.9% to −3.6%; $p < 0.001$), after adjusting for patient characteristics and state and quarter fixed effects. These results remained largely unchanged after additional adjustment for hospital characteristics.

Among non-homeless patients, we found no evidence that readmission and ED revisit rates were lower when treated at teaching hospitals compared to non-teaching hospitals for both medical and surgical conditions. The test of interaction between homeless status and teaching status was statistically significant for readmissions after medical hospitalizations (difference-in-differences, −5.9%; $p < 0.01$ in Model 2) and ED revisits after medical (difference-in-differences, −8.0%; $p < 0.001$ in Model 2) and surgical hospitalizations (difference-in-differences,

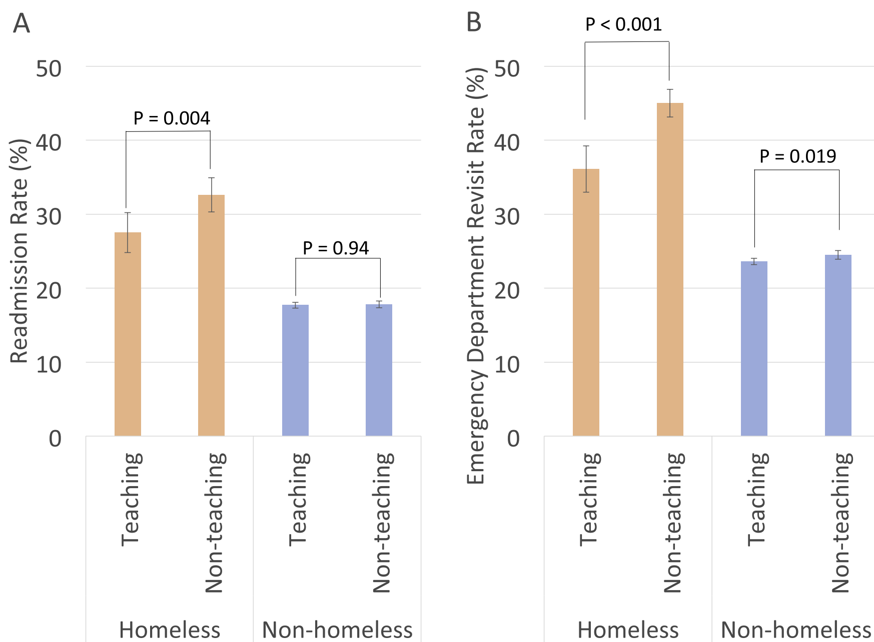


**Fig. 1.** Risk-adjusted rates of 30-day readmission and emergency department revisit after hospital discharge, by homeless status and hospitals' teaching status, adjusting for patient and hospital characteristics. Panel A shows 30-day risk-adjusted readmission rates. Panel B shows 30-day risk-adjusted ED revisit rates. Both results were adjusted for patient characteristics, hospital characteristics, and state and quarter fixed effects (Model 2). Error bars show the 95% confidence intervals.

**Table 5**
Average marginal effects on the rates of 30-day readmission and emergency department revisit after hospital discharge for teaching hospitals compared with non-teaching hospitals, medical vs. surgical conditions.

| | No. of patients | Homeless status | | | | Difference in differences | P value |
|---|---|---|---|---|---|---|---|
| | | Homeless | | Non-homeless | | | |
| | | Average marginal effect, % (95% CI) | P value | Average marginal effect, % (95% CI) | P value | | |
| Readmission | | | | | | | |
| Medical conditions | | | | | | | |
| Model 1 | 2,520,874 | −5.7 (−10.0 to −1.3) | 0.012 | 1.5 (0.8–2.1) | <0.001 | −7.2 (−11.4 to −2.9) | <0.001 |
| Model 2 | 2,520,874 | −5.8 (−10.0 to −1.7) | <0.01 | 0 (−0.7 to 0.7) | 0.94 | −5.9 (−9.9 to −1.9) | <0.01 |
| Surgical conditions | | | | | | | |
| Model 1 | 917,664 | −0.3 (−3.7 to 3.1) | 0.85 | 0.5 (0–0.1) | 0.04 | −0.8 (−4.1 to 2.5) | 0.63 |
| Model 2 | 917,664 | −1.3 (−4.7 to 2.1) | 0.45 | −0.1 (−0.6 to 0.4) | 0.69 | −1.2 (−4.6 to 2.2) | 0.49 |
| Emergency department revisit | | | | | | | |
| Medical conditions | | | | | | | |
| Model 1 | 2,520,874 | −9.7 (−13.9 to −5.4) | <0.001 | −0.6 (−1.2 to 0) | 0.07 | −9.1 (−13.2 to −4.9) | <0.001 |
| Model 2 | 2,520,874 | −8.9 (−12.8 to −5.1) | <0.001 | −1.0 (−1.8 to −0.1) | 0.02 | −8.0 (−11.7 to −4.2) | <0.001 |
| Surgical conditions | | | | | | | |
| Model 1 | 917,664 | −7.7 (−11.9 to −3.6) | <0.001 | −0.9 (−1.4 to −0.3) | <0.01 | −6.9 (−11.0 to −2.7) | <0.001 |
| Model 2 | 917,664 | −7.8 (−12.1 to −3.4) | <0.001 | −0.8 (−1.6 to 0) | 0.06 | −7.0 (−11.3 to −2.7) | <0.01 |

CI: confidence interval. Average marginal effects for teaching hospitals compared to non-teaching hospitals are shown with 95% CIs. Model 1 adjusted for the quarter and state indicator variables and patient characteristics, including the primary diagnosis at index admission, age, sex, race/ethnicity, primary payers, and comorbidities. Model 2 adjusted for all variables included in Model 1 plus hospital characteristics, including profit status, Rural-Urban Commuting Area classification, hospital size, and the presence of medical/cardiac intensive care units.

−7.0%; $p < 0.01$ in Model 2).

### 3.8. Secondary analyses

Our findings were qualitatively unchanged by accounting for the data missing for the indicator of hospital revisits (eTable 4), by the use of the alternative definitions of homeless status (defining homelessness at the point of hospital discharge and ED visit rather than at any time within a given year) (eTable 5), by the use of the alternative definition of hospital teaching status (using intern/resident to beds ratio) (eTable 6), and across categories of patients' severity of illness (eTable 7). When we focused on specific common primary conditions/procedures of hospitalization (eTable 8), lower-level rates of readmissions and ED revisits were observed for teaching hospitals compared to non-teaching hospitals across all the medical conditions (except for acute myocardial infarction), especially among homeless patients, even though differences were not statistically significant for some conditions, possibly due to smaller sample size. For surgical conditions, we did not find consistent patterns of the associations between teaching status and readmission rates in homeless patients; homeless patients experienced lower readmission rates when treated at teaching hospitals for some surgical procedures (e.g., knee arthroplasty and colorectal resection), but had higher readmission rates for others (e.g., hip replacement and coronary artery bypass grafting). Finally, we found no evidence that the placebo outcome ("DaysToEvent") differed between teaching and non-teaching hospitals for both homeless and non-homeless patients (eTable 9).

## 4. Discussion

Using statewide databases from four large and geographically diverse states, we found that homeless patients discharged from teaching hospitals had lower rates of readmission and ED revisit after hospital discharge compared to homeless patients discharged from non-teaching hospitals. Due to the large sample size, we may find statistically significant differences even if the differences were small and not clinically meaningful. However, the estimated differences (average marginal effects) in rates of readmission (5.8 percentage points difference) and ED revisit (9.3 percentage points difference) were arguably large enough to be interpreted as clinically meaningful. We found no evidence that readmission and ED revisit rates differ between teaching and non-teaching hospitals for non-homeless patients. Homeless patients had lower ED revisit rates for both medical and surgical conditions at teaching hospitals, but had a lower hospital readmission rate for only medical conditions. Taken together, these findings suggest that the healthcare settings in which homeless patients receive care have important implications for downstream utilization and costs, as well as for patient outcomes. Considering readmissions and ED revisits are costly for healthcare systems and burdensome for patients, teaching hospitals appear to provide high-quality care to this vulnerable and growing patient population that leads to lower likelihood of hospital readmissions and ED revisits. To our knowledge, this is the first study examining whether rates of hospital readmission and ED revisit differ for homeless patients by hospital teaching status.

It is not clear why these differences exist, but several factors may contribute. First, teaching hospitals may have more experience caring for patients with unstable housing, as they tend to be located in urban areas (98% of teaching hospitals are located in urban areas, and 82% of homeless individuals live in urban/suburban areas (Henry et al., 2018)). They may, therefore, have more incentives and the ability to develop relationships with local governments and social service organizations to help support post-discharge care for homeless patients. Second, teaching hospitals may themselves invest more heavily in the resources and care processes needed to manage care for homeless individuals. Effective transitional care, for example, is important for preventing readmissions, particularly for socially and medically complex patients (Greysen et al., 2012; Kertesz et al., 2009), and teaching hospitals may have more robust discharge planning processes and greater availability of social workers and care managers. Finally, many homeless patients treated at teaching hospitals are cared for in resident clinics, in which trainees are supervised by attending physicians, and it is possible that having more physicians involved in the care of homeless patients has a protective effect with regard to readmission (Barnett et al., 2019).

It is likely that different factors influence medical versus surgical readmission rates for homeless patients. Prior work suggests that social support and care coordination between inpatient and outpatient providers is critical for effective outpatient management of chronic medical conditions, while readmissions for surgical conditions may be driven by in-hospital factors, such as surgical skill and post-operative complications (Kassin et al., 2012; Tsai et al., 2013). Our findings suggest that the lower rate of readmissions at teaching hospitals compared to non-teaching hospitals in the overall inpatient homeless population is mainly explained by differences in readmission rates for medical conditions. Therefore, more robust transitional care, such as quality discharge planning and care coordination, at teaching hospitals may contribute to the lower readmission rates for this vulnerable population. It is also notable that we did not find substantial differences in rates of ED revisit or readmission for non-homeless patients, possibly due to the lower baseline rate of readmissions for non-homeless patients (eTable 1).

Evidence is limited as to whether teaching hospitals perform better than non-teaching hospitals for the treatment of homeless patients. Prior studies have found that the quality of care and patient outcomes may be better at teaching hospitals compared to non-teaching hospitals (Allison et al., 2000; Ayanian and Weissman, 2002; Kupersmith, 2005). More recently, Burke et al. (2017) showed that Medicare beneficiaries who receive treatment at teaching hospitals exhibited lower 30-day mortality than those cared for at non-teaching hospitals. While informative, it is possible that the benefits of receiving care at teaching hospitals vary based on socioeconomic status (SES) of patients. However, to our knowledge, no studies to date have investigated whether teaching hospitals perform better for homeless patients—one of the most vulnerable and underserved populations in the US. This is important from the policy point-of-view, as it is becoming increasingly challenging for policymakers and the health system to adequately address care of the homeless patients (United States Interagency Council on Homelessness, 2015), who are less likely to receive optimal transitional care (Greysen et al., 2012) or cardiovascular procedures (Wadhera et al., 2020) than non-homeless adults. Given that teaching hospitals often have social missions to care for the underserved populations, we hypothesized that homeless patients experience better outcomes when treated at teaching hospitals. Our findings support this hypothesis and indicate that homeless patients benefit more by receiving treatment at teaching hospitals compared with non-homeless patients.

Our study has limitations. First, we identified homeless patients using the information provided directly from hospitals to states. Although hospitals have strong incentives to code homeless status, it is possible homeless indicators were under-coded, (though less likely that non-homeless individuals being coded as homeless). To address this issue, we defined the homeless population as individuals identified as homeless in any encounter with the health system during a given year (instead of only those identified at the time of discharge) in the main analyses. While some homeless individuals may still have been coded as non-homeless, this would bias our estimate toward the null, and the true difference in outcomes, if coded correctly, would be larger than what we have estimated. Second, our analysis was based on association, and therefore, the results should be interpreted with caution. Although we adjusted for a comprehensive set of observed confounders, we could not account for unmeasured confounders. For example, homeless patients who were participating in a homeless program that provides shelter and healthcare might be more likely to be referred to teaching hospitals (given the teaching hospitals' missions to care for the indigent patients (Ayanian and Weissman, 2002)) and have better access to primary care and other post-discharge resources (e.g., housing, shelter supply) compared to homeless patients not participating in such program. Related this, our study was unable to identify the exact mechanisms through which teaching hospitals were showing lower readmission and ED revisit rates for homeless patients, even though lower readmission rates seemed to be derived from care for medical conditions. We did not have information on post-discharge care (e.g., physician visits, non-physician healthcare provider visits, the use of home health care and/or skilled nursing facility), which is known to reduce hospital revisits (Hansen et al., 2011) and be associated with patients' homeless status (Maness and Khan, 2014). Future research with more detailed information on teaching hospitals is warranted to understand why teaching hospitals achieving lower hospital revisit rates. Third, although the current study focused on rates of readmissions and ED revisits because of the health and financial burden of frequent hospital readmissions and ED revisits, quality of care is arguably a multi-dimensional concept, and rates of readmissions and ED revisits would only capture some domains of the quality of care. Finally, because we used data from only 4 states, our findings may not be generalizable to other regions of the country.

## 5. Conclusions

In summary, using statewide databases from four large and diverse states, we found that homeless patients were less likely to be readmitted or return to the ED within 30 days of hospital discharge when treated at teaching hospitals compared to non-teaching hospitals. We found no evidence that acute care utilization after hospital discharge differs between teaching and non-teaching hospitals for non-homeless patients. Our findings suggest that homeless patients may benefit from being cared for at teaching hospitals and that hospital teaching status may have implications for downstream healthcare utilization. Future work should focus on identifying the factors contributing to these differences and where possible, expanding the use of effective strategies to manage care for homeless patients.

## Author contriburion

Atsushi Miyawaki: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Writing - original draft, Visualization, Laura G. Burke: Conceptualization, Methodology, Validation, Investigation, Writing - review & editing, Visualization. Dhruv Khullar: Conceptualization, Methodology, Validation, Investigation, Writing - review & editing, Visualization. Yusuke Tsugawa: Conceptualization, Methodology, Software, Validation, Resources, Data curation, Writing - review & editing, Visualization, Supervision, Project administration, Funding acquisition

## Declaration of competing interest

Dr. L. G. Burke reported receiving grants from the Association of American Medical Colleges and the Emergency Medicine Foundation outside the submitted work.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2020.113283.

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