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Disparities in Care and Mortality Among Homeless Adults Hospitalized for Cardiovascular Conditions

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IMPORTANCE Cardiovascular disease is a major cause of death among homeless adults, with mortality rates that are substantially higher than in the general population. It is unknown whether differences in hospitalization-related care contribute to these disparities in cardiovascular outcomes.

OBJECTIVE To evaluate differences in intensity of care and mortality between homeless and nonhomeless individuals hospitalized for cardiovascular conditions (ie, acute myocardial infarction, stroke, cardiac arrest, or heart failure).

DESIGN, SETTING, AND PARTICIPANTS This retrospective cross-sectional study included all hospitalizations for cardiovascular conditions among homeless adults (n = 24 890) and nonhomeless adults (n = 1 827 900) 18 years or older in New York, Massachusetts, and Florida from January 1, 2010, to September 30, 2015. Statistical analysis was performed from February 6 to July 16, 2019.

MAIN OUTCOMES AND MEASURES Risk-standardized diagnostic and therapeutic procedure rates and in-hospital mortality rates.

RESULTS Of the 1 852 790 total hospitalizations for cardiovascular conditions across 525 hospitals, 24 890 occurred among patients who were homeless (11 452 women and 13 438 men; mean [SD] age, 65.1 [14.8] years) and 1 827 900 occurred among patients who were not homeless (850 660 women and 977 240 men; mean [SD] age, 72.1 [14.6] years). Most hospitalizations among homeless individuals were primarily concentrated among 11 hospitals. Homeless adults were more likely than nonhomeless adults to be black (38.6% vs 15.6%) and insured by Medicaid (49.3% vs 8.5%). After accounting for differences in demographics (age, sex, and race/ethnicity), insurance payer, and clinical comorbidities, homeless adults hospitalized for acute myocardial infarction were less likely to undergo coronary angiography compared with nonhomeless adults (39.5% vs 70.9%; $P < .001$), percutaneous coronary intervention (24.8% vs 47.4%; $P < .001$), and coronary artery bypass graft (2.5% vs 7.0%; $P < .001$). Among adults hospitalized with stroke, those who were homeless were less likely than nonhomeless individuals to undergo cerebral angiography (2.9% vs 9.5%; $P < .001$) but were as likely to receive thrombolytic therapy (4.8% vs 5.2%; $P = .28$). In the cardiac arrest cohort, homeless adults were less likely than nonhomeless adults to undergo coronary angiography (10.1% vs 17.6%; $P < .001$) and percutaneous coronary intervention (0.0% vs 4.7%; $P < .001$). Risk-standardized mortality was higher for homeless persons with ST-elevation myocardial infarction compared with nonhomeless persons (8.3% vs 6.2%; $P = .04$). Mortality rates were also higher for homeless persons than for nonhomeless persons hospitalized with stroke (8.9% vs 6.3%; $P < .001$) or cardiac arrest (76.1% vs 57.4%; $P < .001$) but did not differ for heart failure (1.6% vs 1.6%; $P = .83$).

CONCLUSIONS AND RELEVANCE There are significant disparities in in-hospital care and mortality between homeless and nonhomeless adults with cardiovascular conditions. There is a need for public health and policy efforts to support hospitals that care for homeless persons to reduce disparities in hospital-based care and improve health outcomes for this population.

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In the United States, more than 560 000 people are homeless on any given night,[1] and 1 in 25 will experience homelessness in their lifetime.[2] Homeless individuals have a higher burden of medical comorbidities and also face numerous social challenges, including poor access to food, shelter, and safety. These complex medical and social issues are associated with low life expectancy and high mortality rates among people experiencing homelessness.[3-5]

Cardiovascular disease is a major cause of death among homeless individuals. In addition to a high prevalence of traditional cardiovascular risk factors, such as diabetes, the burden of nontraditional cardiovascular risk factors, such as depression and substance use disorder, is greater in this population.[6] Furthermore, financial and structural barriers impede homeless persons' access to health care services, resulting in delayed and fragmented care, and suboptimal treatment of these risk factors.[6-8] Estimates suggest that cardiovascular mortality rates among homeless adults are up to 3-fold higher than those of nonhomeless individuals.[3,9]

Despite high cardiovascular mortality rates among homeless persons,[6] little is known about whether these broader patterns reflect differences in hospitalization-related care for cardiovascular conditions, such as acute myocardial infarction (AMI), stroke, cardiac arrest, and heart failure. One possibility is that homeless and nonhomeless persons receive similar care during a hospitalization and that worse outcomes in the homeless population are related primarily to access to outpatient care and to factors beyond hospital walls. Alternatively, homeless individuals may also be less likely to receive indicated care during a hospitalization, owing to either within-hospital or between-hospital differences in how they are treated compared with nonhomeless adults, which may be associated with their worse outcomes. Understanding whether homeless adults experience disparities in hospitalization-related care is critically important from a public health perspective, particularly given recent evidence that the homeless population is growing in size and that their rates of acute hospitalization are increasing.[10,11] Such insights could inform targeted interventions to improve health outcomes in this population.

Therefore, in this study, we aimed to answer 3 questions. First, how did demographic and clinical characteristics differ between homeless and nonhomeless adults hospitalized for acute cardiovascular conditions (AMI, cardiac arrest, stroke, or heart failure) in 3 US states from 2010 to 2015? Second, were homeless adults less likely to receive diagnostic and therapeutic procedures for acute cardiovascular conditions compared with nonhomeless adults, after accounting for differences in demographics and clinical comorbidities? If so, was this disparity due to differences in how homeless and nonhomeless adults were treated within the same hospital or, instead, to between-hospital differences in care delivery? And third, did in-hospital mortality differ between homeless and nonhomeless persons?

Key Points

Question Do patterns of care and mortality differ between homeless and nonhomeless adults hospitalized for acute cardiovascular conditions?

Findings In this cross-sectional study of 24 890 hospitalizations for cardiovascular conditions among homeless adults and 1 827 900 hospitalizations for cardiovascular conditions among nonhomeless adults in New York, Massachusetts, and Florida between 2010 and 2015, homeless individuals hospitalized with acute myocardial infarction were significantly less likely to undergo coronary angiography, percutaneous coronary intervention, and coronary artery bypass graft surgery compared with nonhomeless adults and had higher mortality rates for ST-elevation myocardial infarction. Homeless persons hospitalized for cardiac arrest or stroke also received less procedural care and had higher mortality rates.

Meaning There is a need for public health and policy efforts to support hospitals that care for homeless persons, to reduce disparities in hospital-based care, and to improve health outcomes for this population.

Methods

Data Source

We used the State Inpatient Databases of the Healthcare Cost and Utilization Project,[12,13] which are created by the Agency for Healthcare Research and Quality. Each State Inpatient Database includes all inpatient discharges from nonfederal acute-care hospitals and provides information on patient demographics, clinical comorbidities, diagnoses, and expected payer. Data from Massachusetts, New York, and Florida were used because these are populous states with large homeless populations—more than one-quarter of homeless individuals in the United States reside in these 3 states.[14] All inpatient discharges from January 1, 2010, through September 30, 2015, were included in the analysis. We included up to the third quarter of 2015 in our analysis because this was the last year for which data were available. Because the analysis used publicly available deidentified data, institutional review board review at Beth Israel Deaconess Medical Center was waived.

Study Cohort

We included all hospitalizations for all adults aged 18 years or older with a principal discharge diagnosis of AMI, stroke, cardiac arrest, or heart failure. Primary discharge diagnoses were identified using *International Classification of Diseases, Ninth Revision, Clinical Modification* codes, which are shown in eTable 1 in the Supplement.[15,16] We identified hospitalizations among homeless individuals based on whether the patient was documented to be homeless at time of death or discharge.[17] Hospitals are responsible for determining whether a patient is homeless, and this information is then coded and reported directly to the state and retained in the Healthcare Cost and Utilization Project State Inpatient Databases. This approach is used by the Agency for Healthcare Research and

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Quality and has also been used in prior studies.[11,18-20] All other hospitalized adults were classified as nonhomeless.

Outcomes

The primary outcome was in-hospital mortality after hospitalization for an acute cardiovascular condition (AMI, stroke, cardiac arrest, or heart failure). Mortality by type of AMI (non-ST-elevation myocardial infarction [non-STEMI] or ST-elevation myocardial infarction [STEMI]) and by type of stroke (ischemic vs hemorrhagic) was characterized. We also evaluated rates of diagnostic and therapeutic procedures for each respective condition, including coronary angiography, percutaneous coronary intervention (PCI), and coronary artery bypass graft surgery (CABG) for AMI, coronary angiography and PCI for cardiac arrest, cerebral angiography for stroke, and thrombolytic therapy for ischemic stroke.

Statistical Analysis

Statistical analysis was performed from February 6 to July 16, 2019. Continuous variables were summarized by means and SDs and categorical variables as percentages. We first compared patient demographics (age, sex, and race/ethnicity), insurance payer, and clinical comorbidities for the homeless and nonhomeless cohorts using *t* tests and χ^2 tests.

We then categorized hospitalizations among homeless individuals and hospitalizations among nonhomeless individuals into strata based on the following demographic and clinical information: age (5-year intervals), sex (female vs male), race/ethnicity (white, black, Hispanic, or other), insurance type (Medicare, Medicaid, private, or other), and clinical comorbidities.[21] This categorization resulted in 10 260 strata across 4 conditions, each of which contained hospitalizations among homeless and nonhomeless individuals that were defined by a unique combination of these demographic and clinical characteristics. The relative size of each stratum for the homeless cohort (eg, proportion of all homeless hospitalizations included within each stratum) was used to reweight each corresponding nonhomeless stratum. Strata in which there were either no homeless individuals or nonhomeless individuals were removed.[11]

Next, we aggregated strata to generate an overall risk-standardized rate of each procedure for homeless and nonhomeless groups. We then calculated the difference in risk-standardized diagnostic and therapeutic procedure rates between hospitalizations among homeless individuals and hospitalizations among nonhomeless individuals. This calculation was performed separately for each acute cardiovascular condition and then repeated for subtypes of each condition (eg, non-STEMI vs STEMI). We used a similar approach to calculate differences in risk-standardized in-hospital mortality rates between homeless and nonhomeless cohorts for each condition. Overall, this approach allowed us to address potential confounding associated with the demographic and clinical variables used for stratification, to isolate the effect of homelessness, and to compare risk-standardized outcomes between homeless and nonhomeless cohorts.

We also compared procedure rates between homeless and nonhomeless patients admitted to the same hospital, using the same stratification approach for AMI and stroke. We were unable to perform this analysis for cardiac arrest owing to the low number of admissions with cardiac arrest per hospital. This comparison allowed us to understand whether there were within-hospital differences in clinical management between homeless and nonhomeless patients.

Sensitivity Analyses

We performed 2 additional analyses. First, for the primary outcome of condition-specific in-hospital mortality, we determined E-values.[22] Second, we excluded all hospitals with fewer than 50 hospitalizations of homeless individuals and then repeated our main analysis. Race and/or ethnicity was assessed in the study given the association between these patient characteristics and cardiovascular outcomes. Analyses were performed using SAS, version 9.4 64-bit (SAS Institute Inc).

Results

Baseline Characteristics

We identified 1 852 790 total hospitalizations for cardiovascular conditions across the study period, of which 24 890 (1.3%) were among homeless individuals (**Table**). In the homeless group, 5360 hospitalizations were for AMI, 5875 for stroke, 244 for cardiac arrest, and 13 411 for heart failure. Most hospitalizations for cardiovascular conditions among homeless individuals occurred at 11 of the 525 hospitals in the study cohort (**Figure 1**A), while hospitalizations for cardiovascular conditions among nonhomeless individuals were distributed across all hospitals (Figure 1B).

Compared with nonhomeless adults, homeless adults were younger (mean [SD] age, 65.1 [14.8] vs 72.1 [14.6] years), more likely to be black (38.6% vs 15.6%) and insured by Medicaid (49.3% vs 8.5%), and less likely to be insured by Medicare (44.7% vs 71.4%) (Table). Comorbidities differed among homeless and nonhomeless cohorts. Homeless adults had higher rates than nonhomeless adults of alcohol use disorder (7.5% vs 3.4%), drug use disorder (8.4% vs 2.3%), and psychoses (4.4% vs 2.8%). Homeless adults were also more likely than nonhomeless adults to have diabetes (39.0% vs 32.5%) and hypertension (75.9% vs 74.8%) but were otherwise generally less likely to have other comorbidities. The mean (SD) length of stay was longer for the homeless cohort than the nonhomeless cohort (6.9 [11.1] days vs 5.7 [7.3] days), and homeless individuals were less likely to be discharged to a skilled nursing or intermediate care facility (16.7% vs 24.0%) (Table; eTable 2 in the Supplement).

Risk-Standardized Diagnostic and Therapeutic Procedure Rates

Observed procedure rates for each cardiovascular condition are shown in eTable 3 in the Supplement. After risk standardization (for age, sex, race/ethnicity, insurance payer, and clinical comorbidities), homeless adults who were hospitalized for AMI were less likely to undergo coronary angiography compared with nonhomeless adults (39.5% vs 70.9%; difference in

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Table. Baseline Demographic and Clinical Characteristics of Homeless and Nonhomeless Individuals Hospitalized for Cardiovascular Conditions

Characteristic	Patients, No. (%)		
	Homeless (n = 24 890)	Nonhomeless (n = 1 827 900)	Overall (N = 1 852 790)
Acute myocardial infarction, No.	5360 (21.5)	489 966 (26.8)	495 326 (26.7)
STEMI	1073 (4.3)	134 849 (7.4)	135 922 (7.3)
Non-STEMI	4287 (17.2)	355 117 (19.4)	359 404 (19.4)
Stroke, No.	5875 (23.6)	448 968 (24.6)	454 843 (24.5)
Hemorrhagic	1605 (6.4)	96 971 (5.3)	98 576 (5.3)
Ischemic	4270 (17.2)	351 997 (19.3)	356 267 (19.2)
Cardiac arrest, No.	244 (1.0)	15 179 (0.8)	15 423 (0.8)
Heart failure, No.	13 411 (53.9)	873 787 (47.8)	887 198 (47.9)
Age, mean (SD), y	65.1 (14.8)	72.1 (14.6)	72.0 (14.6)
Female sex	11 452 (46.0)	850 660 (46.5)	862 112 (46.5)
Race/ethnicity			
White	4300 (17.3)	1 235 021 (67.6)	1 239 321 (66.9)
Black	9604 (38.6)	284 593 (15.6)	294 197 (15.9)
Hispanic	5044 (20.3)	199 097 (10.9)	204 141 (11.0)
Other[a]	5942 (23.9)	109 189 (6.0)	115 131 (6.2)
Insurance			
Medicare	11 130 (44.7)	1 305 897 (71.4)	1 317 027 (71.1)
Medicaid	12 276 (49.3)	154 546 (8.5)	166 822 (9.0)
Private	276 (1.1)	256 440 (14.0)	256 716 (13.9)
Uninsured or self-pay	1208 (4.9)	111 017 (6.0)	112 225 (6.1)
Comorbidities			
Alcohol use disorder, No./total No. (%)[b]	1788/23 975 (7.5)	54 899/1 607 048 (3.4)	56 687/1 631 023 (3.4)
Anemia	4731 (19.0)	421 311 (23.1)	426 042 (23.0)
Blood loss anemia	103 (0.4)	12 255 (0.7)	12 358 (0.7)
Chronic pulmonary disease	5854 (23.5)	510 739 (27.9)	516 593 (27.9)
Coagulopathy	985 (4.0)	101 654 (5.6)	102 639 (5.5)
Depression, No./total No. (%)[b]	1209/23 975 (5.0)	142 931/1 607 048 (8.9)	144 140/1 631 023 (8.8)
Diabetes			
Without complications	9710 (39.0)	593 822 (32.5)	603 532 (32.6)
With chronic complications	2118 (8.5)	143 510 (7.9)	145 628 (7.9)
Drug use disorder, No./total No. (%)[b]	2005/23 975 (8.4)	37 287/1 607 048 (2.3)	39 292/1 631 023 (2.4)
Heart failure	803 (3.2)	67 682 (3.7)	68 485 (3.7)
Hypertension	18 901 (75.9)	1 367 727 (74.8)	1 386 628 (74.8)
Hypothyroidism	1801 (7.2)	261 623 (14.3)	263 424 (14.2)
Lymphoma	133 (0.5)	15 956 (0.9)	16 089 (0.9)
Solid tumor without metastasis	365 (1.5)	32 350 (1.8)	32 715 (1.8)
Metastatic cancer	183 (0.7)	22 514 (1.2)	22 697 (1.2)
Fluid and electrolyte disorders	5686 (22.8)	489 346 (26.8)	495 032 (26.7)
Neurologic disorder	1135 (4.6)	98 842 (5.4)	99 977 (5.4)
Paralysis	774 (3.1)	50 378 (2.8)	51 152 (2.8)
Peripheral vascular disease	1421 (5.7)	206 168 (11.3)	207 589 (11.2)
Psychoses[b]	1063/23 975 (4.4)	44 440/1 607 048 (2.8)	45 503/1 631 023 (2.8)
Pulmonary circulation disorders	188 (0.8)	18 598 (1.0)	18 786 (1.0)
Renal failure	6646 (26.7)	543 994 (29.8)	550 640 (29.7)
Rheumatoid arthritis or collagen vascular disease	311 (1.3)	47 703 (2.6)	48 014 (2.6)
Peptic ulcer disease	14 (0.1)	497 (0.03)	511 (0.03)
Valvular disease	311 (1.3)	48 169 (2.6)	48 480 (2.6)
Weight loss	714 (2.9)	56 713 (3.1)	57 427 (3.1)
Length of stay, mean (SD), d	6.9 (11.1)	5.7 (7.3)	5.8 (7.4)
Discharge disposition			
Home[c]	11 056 (44.4)	787 183 (43.1)	798 239 (43.1)
SNF, ICF, or other[d]	4156 (16.7)	439 224 (24.0)	443 380 (23.9)

Abbreviations: ICF, intermediate care facility; Non-STEMI, non–ST-elevation myocardial infarction; STEMI, ST-elevation myocardial infarction; SNF, skilled nursing facility.

[a] Includes patients identified as Asian or Pacific Islander, Native American, or "other."

[b] Covariates were missing for 3.7% of the homeless cohort.

[c] Includes discharge to street in the homeless group.

[d] Other includes sites classified as "another type of facility."

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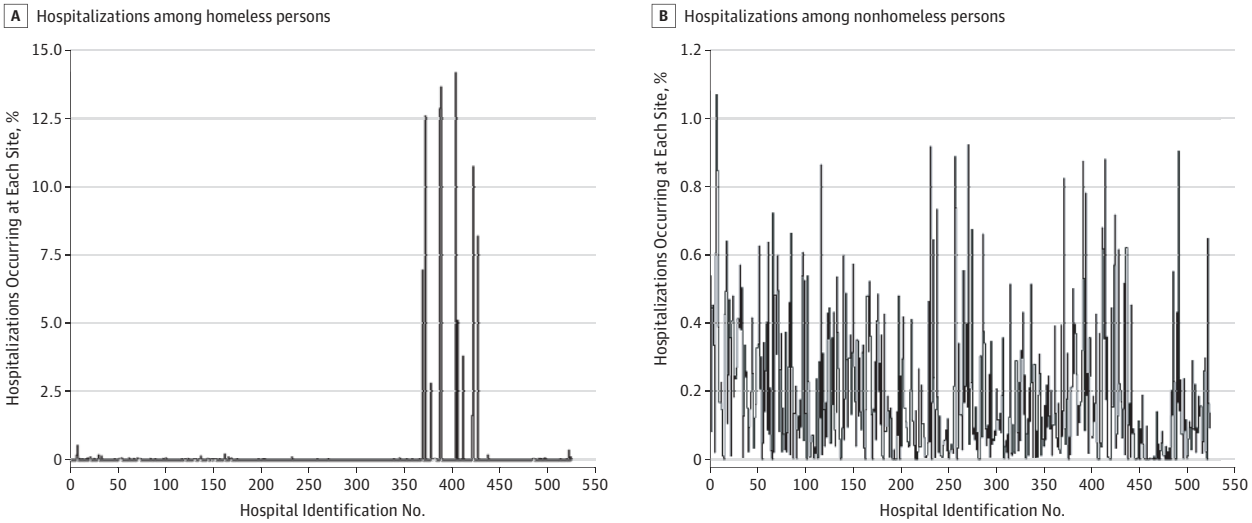
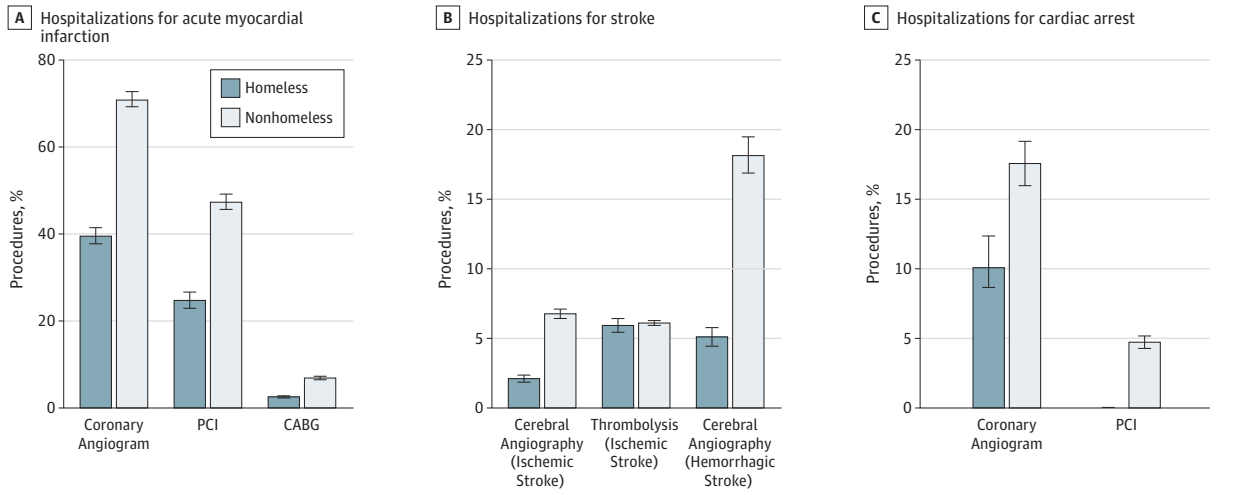
Figure 1. Frequency of Cardiovascular Hospitalizations Among Homeless and Nonhomeless Individuals Across Hospitals



A, Proportion of all cardiovascular hospitalizations among homeless individuals occurring at each hospital site. B, Proportion of all cardiovascular hospitalizations among nonhomeless individuals occurring at each hospital site. The x-axis identifies each hospital site included in the analysis by a unique identification number. The bars represent the proportion of hospitalizations occurring at each hospital site. Cardiovascular hospitalizations occurred at a total of 525 acute-care hospitals across the 3 states.

Figure 2. Risk-Standardized Diagnostic and Therapeutic Procedure Rates Among Homeless and Nonhomeless Adults Hospitalized for Cardiovascular Conditions



A, Patients hospitalized for acute myocardial infarction. B, Patients hospitalized for stroke. C, Patients hospitalized for cardiac arrest. Procedure rates after risk standardization (age, sex, race/ethnicity, insurance payer, and clinical comorbidities) are shown. Standard error bars are shown for each point estimate. CABG indicates coronary artery bypass graft; PCI, percutaneous coronary intervention.

procedure rates between homeless and nonhomeless groups, −31.4% [95% CI for difference, −33.7% to −29.1%]; $P < .001$), PCI (24.8% vs 47.4%; difference, −22.6% [95% CI, −23.8% to −21.4%]; $P < .001$), and CABG (2.5% vs 7.0%; difference, −4.5% [95% CI, −5.2% to −3.8%]; $P < .001$) (**Figure 2**A). In the subgroup of patients with STEMI, risk-standardized rates of coronary angiography were lower in the homeless group compared with the nonhomeless group (55.8% vs 85.9%; difference, −30.2% [95% CI, −34.0% to −26.3%]; $P < .001$), as were rates of PCI (55.4% vs 75.9%; difference, −20.5% [95% CI, −23.5% to −17.4%]; $P < .001$) and CABG (1.7% vs 4.8%; difference, −3.0% [95% CI, −4.1% to −2.0%]). Similarly, among patients with non-STEMI, rates of coronary angiography (35.7% vs 66.1%; difference, −30.4% [95% CI, −32.4% to −28.4%]; $P < .001$), PCI (17.6% vs 37.6%; difference, −20.0% [95% CI, −21.1% to −18.8%]; $P < .001$), and CABG (2.5% vs 7.7%; difference, −5.1% [95% CI, −5.9% to −4.3%]; $P < .001$) were lower in the homeless group vs the nonhomeless group (**Figure 3**).

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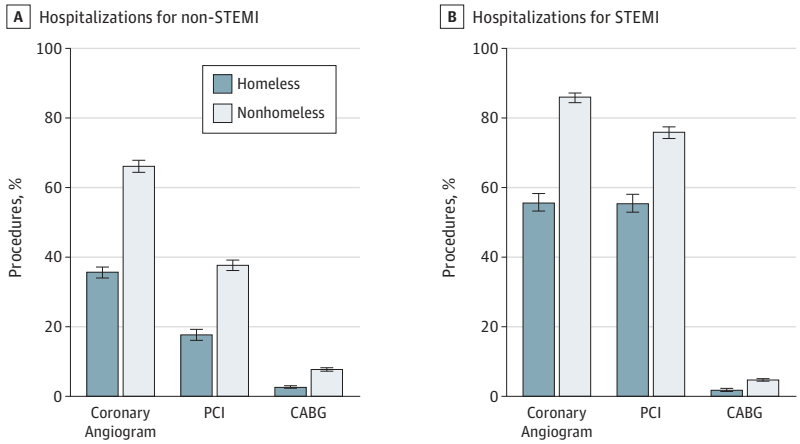
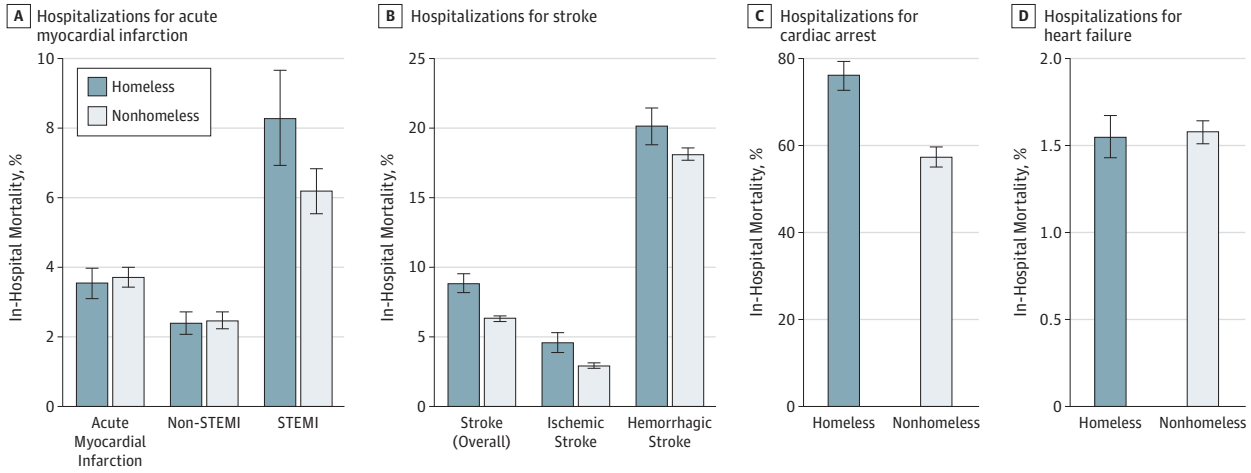
Figure 3. Risk-Standardized Diagnostic and Therapeutic Procedure Rates for Homeless and Nonhomeless Adults Hospitalized for Non–ST-Elevation Myocardial Infarction (non-STEMI) and ST-Elevation Myocardial Infarction (STEMI)



A, Patients hospitalized for non-STEMI. B, Patients hospitalized for STEMI. Procedure rates after risk standardization (age, sex, race/ethnicity, insurance payer, and clinical comorbidities) are shown. Standard error bars are shown for each point estimate. CABG indicates coronary artery bypass graft; and PCI, percutaneous coronary intervention.

Figure 4. Risk-Standardized Mortality Rates Among Homeless and Nonhomeless Adults Hospitalized for Cardiovascular Conditions



A, Patients hospitalized for acute myocardial infarction. B, Patients hospitalized for stroke. C, Patients hospitalized for cardiac arrest. D, Patients hospitalized for heart failure. In-hospital mortality rates after risk standardization (age, sex, race/ethnicity, insurance payer, and clinical comorbidities) are shown. Standard error bars are shown for each point estimate. Non-STEMI indicates non–ST-elevation myocardial infarction; STEMI, ST-elevation myocardial infarction.

Among individuals hospitalized with stroke, those who were homeless were less likely than those who were nonhomeless to undergo cerebral angiography (2.9% vs 9.5%; difference, −6.6% [95% CI, −7.5% to −5.7%]; $P < .001$) but as likely to receive thrombolytic therapy (4.8% vs 5.2%; difference, −0.4% [95% CI, −1.0% to 0.3%]; $P = .28$) (Figure 2B). These patterns were similar among the subgroup of adults with ischemic stroke (cerebral angiography, 2.1% vs 6.7%; difference, −4.7% [95% CI, −5.3% to −4.0%]; $P < .001$; thrombolytic therapy, 5.9% vs 6.1%; difference, −0.2% [95% CI, −1.1% to 0.7%]; $P = .69$). Homeless adults hospitalized with hemorrhagic stroke were also substantially less likely than nonhomeless adults to undergo cerebral angiography (5.1% vs 18.1%; difference, −13.0% [95% CI, −15.5% to −10.5%]; $P < .001$).

In the cardiac arrest cohort, homeless adults were less likely than nonhomeless adults to undergo coronary angiography (10.1% vs 17.6%; difference, −7.5% [95% CI, −11.3% to −3.6%]; $P < .001$). Homeless adults were also less likely to undergo PCI (0.0% vs 4.7%; difference, −4.7% [95% CI, −6.1% to −3.3%]; $P < .001$) (Figure 2C).

Risk-Standardized In-Hospital Mortality Rates

Observed in-hospital mortality rates are shown in eTable 4 in the Supplement. Risk-standardized in-hospital mortality did not significantly differ between homeless (3.5%) and nonhomeless (3.7%) adults hospitalized for AMI (difference, −0.2% [95% CI, −0.8% to 0.4%]; $P = .56$) (**Figure 4**A). For subtypes of AMI, however, mortality was higher among homeless patients hospitalized for STEMI (8.3% vs 6.2%; difference, 2.1% [95% CI, 0.04%-4.2%]; $P = .04$) but no different for those hospitalized for non-STEMI.

Among all hospitalizations for stroke, homeless adults had higher risk-standardized in-hospital mortality rates than their nonhomeless counterparts (8.9% vs 6.3%; difference,

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2.5% [95% CI, 1.4%-3.6%]; $P < .001$). This pattern was also observed among the subgroup of patients with ischemic stroke (4.6% vs 3.0%; difference, 1.6% [95% CI, 0.5%-2.7%]; $P = .003$), although mortality was similar between homeless and nonhomeless adults with hemorrhagic stroke (Figure 4B).

For cardiac arrest, in-hospital mortality rates were higher among homeless adults (76.1% vs 57.4%; difference, 18.8% [95% CI, 13.4%-24.2%]; $P < .001$) compared with nonhomeless adults (Figure 4C). In contrast, mortality among homeless patients hospitalized for heart failure did not significantly differ from the nonhomeless cohort (1.6% vs 1.6%; difference, −0.02% [95% CI, −0.3% to 0.2%]; $P = .83$) (Figure 4D).

Same-Hospital Analysis

To understand whether there were within-hospital differences in clinical management, we also compared standardized procedure rates for AMI and stroke among patients admitted to the same hospital (eTable 5 in the Supplement). Risk-standardized rates of coronary angiography (37.9% vs 46.8%; difference, −8.8% [95% CI, −13.6% to −4.0%]; $P < .001$) and PCI (24.7% vs 28.0%; difference, −3.3% [95% CI, −5.5% to −1.1%]; $P = .001$) were still significantly lower for homeless adults compared with nonhomeless adults hospitalized for AMI at the same site of care. These patterns persisted when stratified by STEMI and non-STEMI. The rates of cerebral angiography (2.8% vs 4.5%; difference, −1.7% [95% CI, −3.2% to −0.1%]; $P = .02$) were lower among homeless adults with stroke than among nonhomeless adults with stroke, although rates of thrombolysis did not differ.

Sensitivity Analysis

E-values for the risk-standardized in-hospital mortality rates between homeless and nonhomeless adults were 1.27 for AMI, 2.15 for stroke, and 1.98 for cardiac arrest. Among the subgroup of patients with STEMI, the E-value for in-hospital mortality was 2.01, and among those with ischemic stroke, the E-value for in-hospital mortality was 2.47. In addition, we repeated our analysis after excluding hospitals with fewer than 50 hospitalizations among homeless individuals across the study period, the findings of which were consistent with our main analysis (eTables 6 and 7 in the Supplement).

Discussion

In this study of homeless adults hospitalized for cardiovascular conditions, we observed significant disparities in the use of diagnostic and therapeutic procedures compared with nonhomeless adults, even after accounting for differences in demographics (age, sex, and race/ethnicity), insurance payer, and clinical comorbidities. These patterns of procedure use were, in part, explained by within-hospital differences in the clinical management of homeless and nonhomeless patients. More importantly, we also found that risk-standardized in-hospital mortality rates for most cardiovascular conditions were substantially higher among homeless persons.

There has been significant concern about the health outcomes of homeless individuals in the United States, particularly because this population is now growing and the number of individuals who are homeless and elderly is projected to triple by 2030.[10,23] Despite greater policy and public health focus, homeless persons have premature mortality and high mortality rates, in part due to cardiovascular disease.[5] A study of homeless adults residing in Philadelphia, Pennsylvania, in the 1980s found that heart disease was the second leading cause of death,[4] and more recent evidence from the Boston Health Care for the Homeless Program has shown that heart disease remains a major cause of death among homeless adults,[3] unchanged compared with 15 years prior.[24] Our findings build on these prior studies by focusing on hospitalization-related care and outcomes in a contemporary cohort of homeless adults admitted for acute cardiovascular conditions across 3 states.

We observed important differences in care and mortality for homeless patients compared with their nonhomeless counterparts. Homeless adults with AMI, for example, underwent coronary angiography at approximately half the rate of similar nonhomeless adults. This finding suggests that clinicians were less likely to pursue a diagnostic procedure often needed to guide therapeutic decision-making, resulting in lower rates of PCI and CABG in the homeless cohort. More important, among the subgroup of patients with STEMI, a condition for which urgent revascularization is indicated, homeless individuals were less likely to undergo coronary angiography (55.8% vs 85.9%) or PCI (55.4% vs 75.9%) than nonhomeless persons. These differences may explain the high in-hospital mortality rates among homeless patients hospitalized for STEMI. We also found similar gaps in care for other cardiovascular conditions. Condition-specific procedure rates were much lower among homeless individuals hospitalized for cardiac arrest or stroke, and associated mortality rates were substantially higher. In contrast, mortality did not differ among patients with heart failure, possibly because their outcomes are less dependent on the delivery of specific procedures.

There are several potential explanations as to why homeless patients receive lower-intensity care for acute cardiovascular conditions. Most concerning is the possibility that homeless patients are treated differently for nonclinical reasons, as suggested by the within-hospital differences in care observed in our study. Prior investigations have demonstrated racial/ethnic and sex disparities in the delivery of life-saving procedural interventions for AMI,[25,26] potentially due in part to implicit bias.[27,28] It is possible that the stigma associated with homelessness also contributes to disparities in care during a hospitalization. These differences in procedural care were not primarily a problem of insurance coverage, given that only a small minority of the homeless individuals in our study were uninsured.

Alternatively, other factors not captured in our study may explain these patterns. For instance, homeless persons face structural barriers that can result in late presentation to acute care facilities for emergency conditions, potentially limiting clinicians' ability to deliver potentially life-saving interventions. In addition, decision-making on whether to perform

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procedures for homeless patients, such as PCI for AMI, may be affected by concerns about lack of adherence to medications (eg, dual antiplatelet therapy) and the potential for downstream harm. Homeless persons often face financial barriers to obtaining prescription medications and experience competing priorities (eg, food and shelter), which may impede adherence.[6,29,30] Efforts to tailor decision-making regarding the delivery of cardiovascular procedures (eg, PCI) to the circumstances of each individual patient, to use case management services, and to provide close, integrated follow-up care could mitigate concerns about adherence and reduce disparities in care intensity for homeless persons with acute cardiovascular conditions.[6]

The cumulative burden of cardiovascular, psychosocial, and environmental risk factors may also be associated with worse outcomes in the homeless population. Homeless individuals often lack reliable access to a usual source of care.[31] This lack of access impedes the delivery of primary and preventive care, as well as the timely diagnosis and treatment of disease, particularly given the unique barriers to medication access and adherence that this population faces.[30] As a result, compared with the general population, homeless individuals often have poorer blood pressure control,[32] greater complications associated with diabetes,[33] and high rates of cigarette smoking,[34,35] all of which are associated with excess cardiovascular mortality.[6] Furthermore, high rates of serious mental illness (eg, schizophrenia), posttraumatic stress disorders, and polysubstance use also are associated with worse cardiovascular outcomes in this population.[36-42]

Our findings have important policy implications. Most hospitalizations for homeless adults were concentrated at a small number of hospitals, and when we evaluated homeless and nonhomeless persons treated at the same sites, differences in procedural care were partially attenuated. This finding indicates that hospitals caring primarily for homeless persons may have limited resources and services that may be associated with disparities in delivery of care. In addition, these hospitals are likely to be safety-net institutions that care for other vulnerable populations of people who may also face similar barriers to accessing primary or follow-up care and adhering to medications. Although the Patient Protection and Affordable Care Act expanded Medicaid eligibility and increased funding for outpatient health centers that care for homeless persons, our findings suggest that policy initiatives should also focus on supporting hospitals that primarily serve this population. Providing additional resources to safety-net hospitals—whether financial or in-kind—to implement multidisciplinary care pathways, enhance care coordination, facilitate transitions to medical respite units,[43] and provide intensive case management specifically for homeless individuals, coupled with ongoing efforts to enhance longitudinal access to ambulatory health care services and promote housing stability through a "housing first" approach,[44-47] could collectively help improve health outcomes in this highly vulnerable population.

Limitations

This study has some limitations. First, we focused on homeless hospitalizations in only 3 states, which may not be representative of the homeless population in the United States. Nonetheless, more than one-quarter of the homeless population in the United States resides in the 3 states examined in our study.

Second, our analysis was observational and may not have captured unmeasured differences in acuity of illness between homeless and nonhomeless patients. However, our stratification approach accounted for important observable differences between these populations, including age, sex, race/ethnicity, insurance payer, and clinical comorbidities. Third, homelessness was defined based on whether a hospital directly reported a patient to be homeless at the time of discharge or death. We suspect that this method is reasonably specific in that hospitals are unlikely to make this designation in the absence of housing problems. However, given that the spectrum of housing issues is large, this approach may not have captured individuals who experienced housing insecurity or who were transiently homeless.[48] In addition, we were unable to determine the approach used by hospitals to obtain and record information about homelessness, and it is possible that there was variation in the definition of homelessness across hospitals. Finally, we were unable to investigate postdischarge care patterns and outcomes in the homeless population, which represent important areas for future study.

Conclusions

We found that mortality rates were higher among homeless persons than nonhomeless persons hospitalized with acute cardiovascular conditions, even after accounting for differences in demographics (age, sex, and race/ethnicity), insurance payer, and clinical comorbidities. We also observed substantially lower use of potentially life-saving procedures for homeless adults, which may explain differences in mortality. This finding was explained, in part, by within-hospital differences in the clinical management of these populations. Further qualitative research is needed to understand how health care professional decision-making, when caring for homeless individuals, contribute to these patterns of care. Collectively, our findings suggest a need for public health and policy efforts to focus on reducing disparities in hospital-based acute care for homeless individuals to improve health outcomes in this population.

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