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Authors

Yeh, Savannah L
Chen, Alina J
Ulloa, Jesus G
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Impact of Housing Insecurity on Outcomes in Abdominal Aortic Aneurysm Repair Among Veterans

Savannah L. Yeh,[1] Alina J. Chen,[1] Jesus G. Ulloa,[2,3] David A. Rigberg,[2,3] Christian M. de Virgilio,[3,4,5] Jessica B. O'Connell,[2,3] and Hugh A. Gelabert,[2,3] Los Angeles and Torrance, California

Background: Veterans are disproportionately affected by housing insecurity (HI), which can lead to adverse health outcomes and reduced life expectancy. We sought to examine the impact of HI on the outcomes of veterans who underwent abdominal aortic aneurysm (AAA) repair at our regional Veterans Affairs medical center.

Methods: Retrospective chart review was performed on patients who underwent AAA repair at our institution between January 1, 2000, and December 31, 2020. We examined medical history, procedure details, hospitalization course, and postoperative outcomes. Primary endpoints were a 30-day mortality and median survival. Secondary endpoints were hospital length of stay, readmission rate, and perioperative complications. Hypothesis testing was performed with *t*-test and chi-squared analysis. Survival analysis was conducted using Kaplan−Meier estimation.

Results: Of the 314 veterans that underwent AAA repair (mean age of 71.4 ± 7.8 years, 99.7% male) over the 21-year period, we identified 39 (12.4%) patients with a history of HI. The HI was associated with a positive smoking history (100% vs. 88.0%, $P = 0.022$), lower rate of hypertension diagnosis (69.2% vs. 84.0%, $P = 0.024$), and increased rate of surgical site infections (SSI) (10.3% vs. 1.8%, $P = 0.016$). The median postoperative survival was lower in the HI group (7.6 years [CI 6.0−11.2] vs. 8.9 [CI 6.9−10.3]).

Conclusions: HI was associated with reduced median postoperative survival, greater readmission rate, and increased risk of SSI following AAA repair.

INTRODUCTION

Nearly 580,500 people were experiencing homelessness in the United States on a single night in 2020 and approximately 8% were veterans.[1] Homeless individuals are more likely to have reduced access to care and adverse health outcomes. Numerous studies have shown homelessness to be associated with higher age-adjusted mortality rate, reduced life expectancy, and higher morbidity.[2,3] Veterans are disproportionately affected by homelessness, psychiatric illness, and

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[1]*David Geffen School of Medicine, University of California, Los Angeles, CA.*

[2]*Division of Vascular and Endovascular Surgery, David Geffen School of Medicine, University of California, Los Angeles, CA.*

[3]*Department of Surgery, VA Greater Los Angeles Healthcare System, Los Angeles, CA.*

[4]*Department of Surgery, Harbor-UCLA Medical Center, Torrance, CA.*

[5]*Lundquist Institute of Biomedical Research, Harbor-UCLA Medical Center, Torrance, CA.*

Correspondence to: Savannah L. Yeh, BS, Surgical & Perioperative Careline, VA Greater Los Angeles Healthcare System, 11301 Wilshire Blvd (10H2), Los Angeles, CA 90073, USA; E-mail: syeh@mednet.ucla.edu

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chronic diseases.[4] While it is known that homelessness is associated with greater unmet health care needs and greater utilization of emergency health services,[5] it is important to understand how housing affects surgical outcomes in this vulnerable population.

Each year 40,000 patients in the United States undergo elective surgical repair of abdominal aortic aneurysms (AAA),[6] 5,000 of which are performed at Veterans Affairs (VA) hospitals.[7] Veterans are at greater risk of vascular disease[8] and homeless men are at increased risk of peripheral arterial disease (PAD) compared to the general population.[9] Homeless veterans and formerly homeless veterans have been found to have higher emergency room utilization than their housed peers.[4] They are also more likely to be readmitted following orthopedic, general, and vascular surgery.[10] However, little is known about outcomes in homeless veterans following AAA repair.

The objective of this study was to characterize the veteran population undergoing repair of aortic aneurysms at our institution, and to investigate the effect of housing insecurity (HI) on outcomes following AAA repair in our veteran population.

METHODS

A retrospective review was conducted of all AAA repair procedures performed at the VA Greater Los Angeles Healthcare System between January 1, 2000, and December 31, 2020. Patients were selected from the procedure database maintained by the vascular surgery service and confirmed to have undergone the procedure upon chart review on Computerized Patient Record System. All patients who underwent open aneurysm repair (OAR) or endovascular aneurysm repair (EVAR) for an AAA (juxtarenal, pararenal, and infrarenal) were included. Both emergent and elective cases were included. Emergent procedures were defined as repairs noted as unplanned and emergent in the preoperative vascular surgery note or unplanned repairs performed within 12 hr of an admission through the emergency department. The study was approved by the local institutional review board and conducted in accordance with their protocol.

Baseline Characteristics

HI was defined as patients with a past or current diagnosis of homelessness, inadequate housing, or housing instability at baseline based on the International Classification of Diseases-10 diagnosis (Z59.0, Z59.1, Z59.81) in the electronic medical record (EMR). Patients with documentation of a history of sheltered or unsheltered homelessness in the preoperative medicine note or vascular surgery consult note were included. Baseline demographics included age at time of procedure, sex, race, and ethnicity. Medical history, comorbid conditions, procedure details, and follow-up details were also collected. Hypertension was defined as the documented diagnosis of hypertension and use of medication indicated for treatment of hypertension. Diabetes mellitus was defined as the documented diagnosis of the condition and use of medication for diabetes treatment. Hyperlipidemia was defined as the documentation of hyperlipidemia or statin use at the time of procedure. Additional medical history and comorbidities collected based on the documentation in the EMR included history of smoking, myocardial infarction (MI), coronary revascularization, coronary artery disease, chronic obstructive pulmonary disease, PAD, cancer (excluding primary skin malignancies), and psychiatric illness. Psychiatric illness included psychotic disorders, mood disorders (depression, bipolar, and other), and substance use disorders (alcohol and illicit drugs). Frailty was defined as a score $\geq$2 on the modified 5-Factor Frailty Index (mFI-5) following criteria validated in previous studies.[11,12]

Study Variables

The primary outcome measure was a 30-day mortality and median postoperative survival. Secondary outcome measures were length of hospital stay following procedure, unplanned readmission rate within 30 days of discharge, and postoperative complication rate. Length of hospital stay was calculated from postoperative day 1 to the day of discharge from hospital. Early complications were defined as events within 30 days following the procedure. Late complications were defined as complications that began more than 30 days following the procedure as noted in vascular surgery clinic follow-up notes.

Statistical Analysis

Continuous variables were summarized as mean and standard deviation and were analyzed using independent *t*-test. Categorical variables were described in frequencies and analyzed using chi-squared test. For categorical variables with $\geq$20% of expected frequencies lower than 5, Fisher's exact

Table I. Overview of AAA repair and housing status

AAA repair overview	History of housing insecurity ($n = 39$)	No history of housing insecurity ($n = 275$)	*P*-value
Demographics			
Mean patient age-years	69.3 ± 8.2	71.7 ± 7.7	0.038
Male sex-no. (%)	39 (100.0)	274 (99.6)	0.706
African American or Black-no. (%)	10 (25.6)	53 (19.3)	0.353
Non-Hispanic Caucasian-no. (%)	26 (66.7)	179 (65.1)	0.847
Medical history-no. (%)			
Myocardial infarction	6 (15.4)	42 (15.3)	0.986
Coronary revascularization	8 (20.5)	69 (25.1)	0.534
Coronary artery disease	13 (33.3)	110 (40.0)	0.425
Congestive heart failure	1 (2.6)	37 (13.5)	0.063
Stroke/transient ischemic attack	4 (10.3)	27 (9.8)	0.932
Peripheral vascular disease	8 (20.5)	65 (23.6)	0.666
Hyperlipidemia	31 (79.5)	216 (78.5)	0.893
Hypertension	27 (69.2)	231 (84.0)	0.024
Chronic obstructive lung disease	13 (33.3)	76 (27.6)	0.460
Cancer	8 (20.5)	57 (20.7)	0.975
Diabetes mellitus	9 (23.1)	77 (28.0)	0.519
Social factors-no. (%)			
Prior smoking	39 (100.0)	242 (88.0)	0.022
Currently smokes	18 (46.2)	122 (44.4)	0.833
One or more psychiatric diagnosis	22 (56.4)	119 (43.3)	0.123
Modified 5-Factor Frailty Index (preoperative)			
mFI-5 $\geq$ 2-no. (%)	15 (38.5)	111 (40.4)	0.821
mFI-5-mean	1.3 ± 1.0	1.4 ± 1.1	0.593
AAA characteristics/operative details			
AAA size-mean	5.9 ± 1.1	5.9 ± 1.4	0.937
EVAR-no. (%)	27 (69.2)	172 (62.5)	0.417
Emergent cases-no. (%)	2 (5.1)	12 (4.3)	0.688
Ruptured AAA-no. (%)	1 (2.6)	10 (3.6)	1.000

test was used. Survival analysis was conducted using the Kaplan—Meier estimator and log-rank test to compare the 2 housing groups. A *P*-value < 0.05 was considered significant. Hazard ratios (HR) and 95% confidence intervals (CI) were obtained using Cox regression analysis. HRs were constructed for 2 distinct time periods to satisfy the proportional hazard assumption. Statistical analyses were performed using XLSTAT (Addinsoft Inc, New York, NY). The Cox regression analysis was performed using R 4.1.0 (R Core Team, 2021).

RESULTS

Baseline Characteristics

A total of 314 patients underwent AAA repair during the study period. The mean patient age was 71.4 years and only one patient was female (Table I). There were 199 (63%) EVAR procedures and 115 (37%) OARs. The number of OARs steadily decreased while the number of EVARs increased across the 20-year study period (Fig. 1). The frequency of EVAR and OAR was similar between housed and unhoused groups. The average AAA diameter was 5.9 cm (±1.4 cm). Thirty-nine (12%) patients were identified as having HI and 275 (88%) had no HI. The demographics and medical history of the 2 groups were similar except the HI group had a lower observed frequency of diagnosed hypertension and a greater frequency of prior smoking history. There were no differences in age, race, or psychiatric history between the 2 groups.

Postoperative Outcomes

Postoperative outcomes are summarized in Table II. Patients with HI had a greater average length of hospital stay compared to patients without HI (10.4 days ± 29.2 vs. 5.9 days ± 11.6, $P = 0.041$). The unplanned 30-day readmission rate was also greater in patients with HI (15.4% vs. 5.1%, $P = 0.012$). Overall, there were a total of 9 surgical

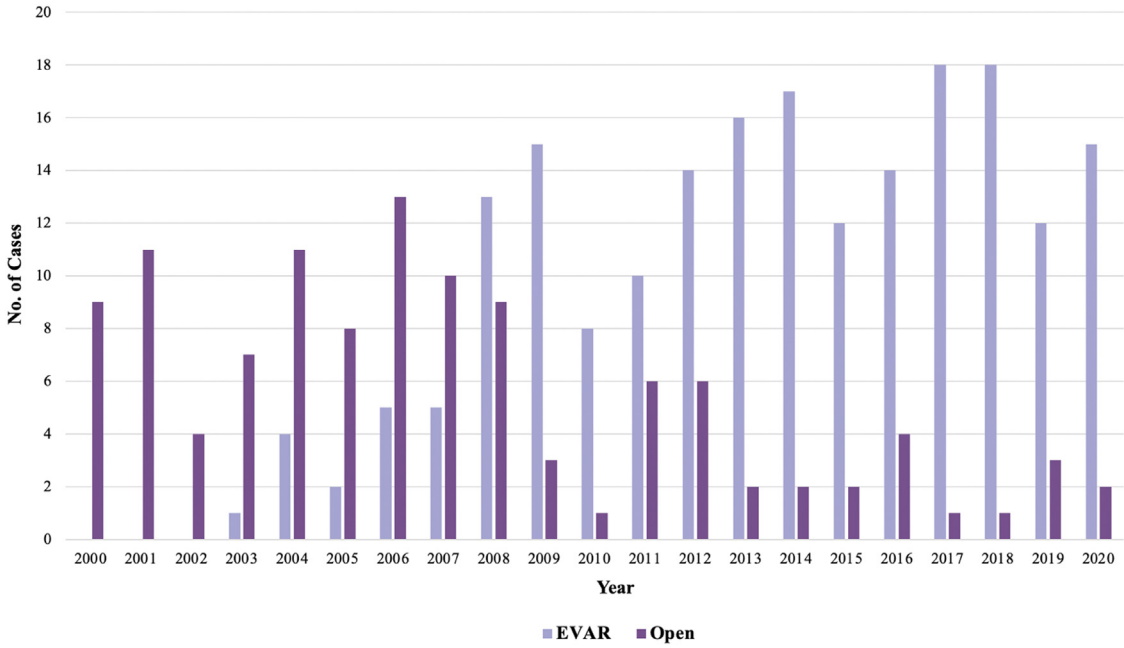


Fig. 1. AAA surgical approach by year.

site infections (SSI) with the majority (88.9%) seen in patients who underwent OAR. Patients with HI had a greater overall rate of SSI (10.3% vs. 1.8%, $P = 0.003$) and a higher rate of SSI following OAR compared to their housed counterparts who underwent OAR (33% vs. 3.9%, $P = 0.004$) (Fig. 2). However, there were no differences in the rates of other early complications including MI, stroke, and pneumonia. The overall and individual rates of late complications were comparable between housing groups.

Survival and Long-Term Hazard

The 30-day mortality rate was similar between the groups (0% vs. 1.5). The survival curves stratified by housing status are depicted in Figure 3. The median postoperative survival among patients with HI was 7.6 years (95% CI [6.0, 11.2]) compared to 8.9 years (95% CI [6.9, 10.3]) with a log-rank *P*-value of 0.046 (Table II). All 39 patients with HI died during the follow-up period.

Cox regression analysis showed survival within the first 7.5 years was similar between the 2 groups (HR 0.99 [0.58, 1.70]) (Fig. 3). After 7.5 years, patients with HI were 3.48 times more likely to die (HR 3.48 [1.76, 6.89], $P = 0.0003$) than their counterparts without HI.

DISCUSSION

Our study demonstrated that HI was not associated with increased mortality within 30 days following AAA repair. Overall long-term survival was lower in the HI group, which has been described in the other adult homeless populations.[1–3] Although, the cause of mortality was not the focus of this study, the increase in mortality in patients with HI is likely unrelated to the procedure given the duration of postoperative survival and the presence of other risk factors associated with HI such as smoking.

The average length of stay was longer for the HI group. Longer length of admission may be related to difficulty discharging patients to an appropriate setting after surgery or may be related to other complications that were not abstracted in our study. Readmission rate was greater among the HI group, which is consistent with previously published literature.[10] However, it is unknown whether readmissions were related to the procedure or an unrelated cause. It is possible that homeless patients are more often hospitalized given their frequent use of emergency services, or that providers exercise a lower threshold for admission given the increased risk of inadequate continuity of care or lack of access to safety net community services.

Table II. Outcomes based on housing status

Perioperative course and outcomes	History of housing insecurity ($n = 39$)	No history of housing insecurity ($n = 275$)	*P*-value
Hospitalization and follow-up			
ICU length of stay-days	8.4 ± 28.9	4.5 ± 10.4	0.027
Total length of stay-days	10.4 ± 29.2	5.9 ± 11.6	0.041
30-day readmission-no. (%)	6 (15.4)	14 (5.1)	0.012
Perioperative complications (≤30 days postoperative)-no. (%)			
Myocardial infarction	0 (0.0)	7 (2.5)	0.603
Stroke	0 (0.0)	1 (0.4)	1.000
Acute renal failure or new dialysis	3 (7.7)	8 (2.9)	0.144
Surgical site infection	4 (10.3)	5 (1.8)	0.016
Graft infection	1 (2.6)	2 (0.7)	0.329
Pulmonary embolism	0 (0.0)	1 (0.4)	1.000
Pneumonia	2 (5.1)	10 (3.6)	0.650
Other early complications[a]	1 (2.6)	8 (2.9)	0.904
One or more early complication	12 (30.8)	50 (18.2)	0.065
Late complications (>30 days postoperative)-no. (%)			
Erectile dysfunction	1 (2.6)	10 (3.6)	1.000
New or worsened claudication	2 (5.1)	30 (10.9)	0.396
AAA enlargement	4 (10.3)	18 (6.5)	0.397
AAA rupture	0 (0.0)	0 (0.0)	-
Graft migration	0 (0.0)	1 (0.4)	0.706
One or more late complications	9 (23.1)	56 (20.3)	0.696
Postoperative mortality and survival			
30-day mortality-no. (%)	0 (0.0)	4 (1.5)	1.000
6-month mortality-no. (%)	2 (5.1)	10 (3.6)	0.650
1-year mortality-no. (%)	4 (10.3)	16 (5.8)	0.291
Median survival-years [95% CI]	7.6 [6.0, 11.2]	8.9 [6.9, 10.3]	0.046

ICU, intensive care unit.
[a]Other early complications include hematoma, postoperative small bowel obstruction, and postoperative ileus.

HI patients had a higher rate of one or more early complications within 30 days post procedure, but this difference was not statistically significant. The rate of SSI was much greater in patients with HI, which may be related to a lack of access to sanitary living conditions or inadequate hygiene. A small case-control study found that deprivation, which included homelessness and psychiatric illness, was a risk factor for SSI among veteran patients.[13] These findings may warrant further investigation and the need to develop strategies to minimize risk of readmission and postoperative complications, specifically SSI, in unhoused populations.

Some of our findings on baseline characteristics are consistent with studies examining similar patient populations. Titan et al. (2018) found that homeless veterans who underwent surgery across various specialties including vascular surgery were younger, less likely to have hypertension, and more likely to have a psychiatric comorbidity.[10] While our patients with HI were younger and less likely to have hypertension, there was no significant difference in frequency of psychiatric illness based on housing status. It should be noted that our study

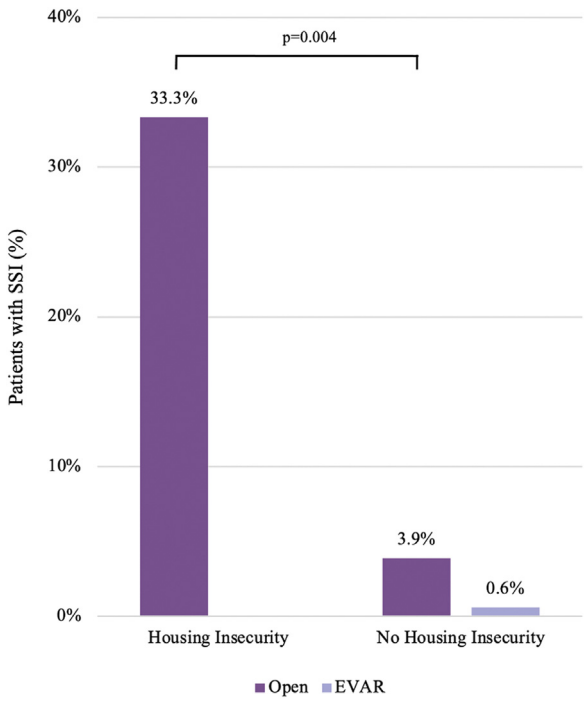
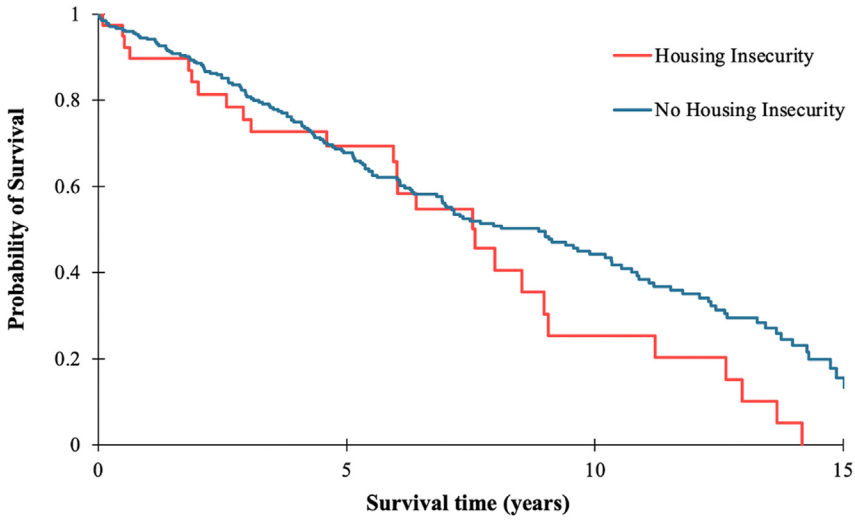


Fig. 2. Surgical site infection rate by surgical approach.



No. at Risk

Unhoused	39	22	6	
Housed	275	148	59	8
Total	314	170	65	8

Fig. 3. Survival distribution by housing status.

did not examine differences in the type of psychiatric illness or whether patients were currently being treated for a psychiatric illness. However, since veterans are at higher risk of mental illness[4] and homelessness may further increase this risk, it is important to consider how these factors may affect our patients undergoing AAA repair. Some population-based studies have examined the association of depression and AAA. Kim et al. (2021) found that patients with an AAA diagnosis or who underwent AAA repair were 1.4 times more likely to be diagnosed with clinical depression.[14] Another study found the risk of AAA was 30% greater in individuals with depressive symptoms compared to the general population.[15] Since our veteran patients with a history of homelessness may be at higher risk of psychiatric comorbidities such as depression, it is important to consider these factors before and after AAA repair.

Limitations

Our retrospective study is limited by the inability to standardize the way medical history was collected and documented. For the purposes of our study, we did not distinguish between a history of HI and current homelessness. Furthermore, we did not distinguish between homelessness and other forms of HI such as financial problems related to inability to pay rent or eviction. Given the retrospective nature of the study, we were not able to fully examine other social determinants of health that can be related to HI such as Area Deprivation Index, nutrition and access to health food, and access to transportation. Additionally, we were unable to determine adequacy of treatment for comorbidities including psychiatric conditions, which affect mortality. The study includes data over the course of nearly 20 years and resources and support for homeless veterans may have evolved over that time frame, but we are unable to assess the utilization of those resources over our study period. Future studies should examine the impact of factors such as discharge location, utilization of VA housing programs, severity of presentation, and comorbidities on outcomes following repair in this population.

CONCLUSION

HI was not associated with increased 30-day postoperative mortality in our veteran population. However, homeless patients had a longer average length of hospital stay, greater readmission rate, and

increased risk of SSI. Further study into mitigating these risks is needed.

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