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An analysis of homeless patients in the United States requiring ICU admission

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ABSTRACT

Purpose: To assess how homelessness impacts mortality and length of stay (LOS) among select the intensive care unit (ICU) patients.

Methods: We used ICD-9 code V60.0 to identify homeless patients using the Premier Perspective Database from January 2010 to June 2011. We identified three subpopulations who received critical care services using ICD-9 and Medicare Severity Diagnosis Related Groups (MS-DRG) codes: patients with a diagnosis of sepsis who were treated with antibiotics by Day 2, patients with an alcohol or drug related MS-DRG, and patients with a diabetes related MS-DRG. We used multivariable logistic regression to predict mortality and multivariable generalized estimating equations to predict hospital and ICU LOS.

Results: 781,540 hospitalizations met inclusion criteria; 2278 (0.3%) were homeless. We found homelessness had no significant adjusted association with mortality among sepsis patients, but was associated with substantially longer hospital LOS: (3.7 days longer; 95% CI (1.7, 5.7, $p < .001$). LOS did not differ in the Diabetes or Alcohol and Drug related DRG groups.

Conclusions: Critically ill homeless patients with sepsis had longer hospital LOS but similar ICU LOS and mortality risk compared to non-homeless patients. Homelessness was not associated with increased LOS in the diabetes or alcohol and drug related groups.

1. Introduction

Lower socioeconomic status has been shown to correlate with worse health care outcomes. [1,2]. Adler and Newman state that socioeconomic status (SES) is associated with three determinants of health: access to health care, environmental exposure, and personal health behaviors [2]. Chronic stress associated with low SES may also increase morbidity and mortality [2]. While seemingly intuitive, quantifying the impact of low SES on health outcomes is challenging with variables like race, education level, census region, and income frequently serving as surrogate measures [3,4]. Homeless patients in the United States represent the extreme end in terms of socioeconomic status. Prior studies of homelessness and hospitalization in the United States have primarily focused on emergency department (ED) visits [5-9]. These studies found homeless patients had more frequent ED visits than non-homeless patients and were more likely to present with mental health disorders, alcoholism, substance abuse, and injuries [5-8].

As homeless patients represent the extreme end in socioeconomic status, patients in the intensive care unit (ICU) represent the extreme end of acuity in hospitalized patients. In 2017, approximately 550,000 patients were homeless on a given night in the United States and approximately 1.5 million used an emergency shelter or transitional housing program within a 12-month period [10,11]. Surprisingly, there is little research on homeless patients in the ICU [12]. In this study, we examine outcomes in homeless patients in a contemporary, nationally representative population of ICU patients in the United States.

2. Methods

We conducted a retrospective, observational cohort analysis using data from the multi-center Perspective Database (now known as the Premier Data Warehouse) from January 2010 to June 2011. The

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database is maintained by Premier Healthcare Informatics, Charlotte, NC. It is a voluntary, fee-supported database created to measure quality and health care utilization. It contains a date-stamped log of all items and services charged to the patient or insurer (such as medications, laboratory tests, diagnostic and therapeutic services) in addition to the elements found in hospital claims derived from the uniform billing 04 (UB-04) form. Participating hospitals represent all regions of the United States and are predominantly small to mid-sized non-teaching facilities that serve urban populations. The database has been described in more detail elsewhere [13-16].

We included patients age 18 or older in the ICU by day 2 of their hospitalization. ICU status was determined by date-stamped room and board charges in the patient record. All hospitalizations were required to have a known in-hospital mortality outcome and patients could not be still hospitalized by the end of the study period. All patients were further required to have a known Medicare Severity-Diagnosis Related Group (MS-DRG) Version 25 code as this information was used to define certain patient subgroups. Patients transferred to an acute care hospital were excluded. Homeless status was determined by the International Classification of Diseases, Ninth Revision (ICD-9) code of V60.0 (lack of housing/homeless). See Supplemental Table 1.

We defined the primary outcomes to be: in-hospital mortality, length of stay (LOS), and ICU LOS. As a sensitivity analysis, we examined LOS among survivors only. We created a large number of treatment variables present by day 2 of hospital admission such as antibiotics, vasopressors, and invasive mechanical ventilation with standardized charge codes. Using the presence of ICD-9 and MS-DRG codes, additional variables were created for the analysis. Chronic comorbidities were derived based on the definitions from Elixhauser. [17] The presence of pneumonia on admission (either a principal or secondary diagnosis) was based on the ICD-9 codes of 481, 482, 483.x, 485, 486 identified by Lindenauer et al. and further expanded to include 480.x and 487.0. [18].

MS-DRGs related to alcohol or drug abuse, sepsis, and diabetes were the most commonly observed in the homeless cohort. See Supplemental Table 2. Consequently, to reduce unmeasured confounding by examining all ICU patients, we defined three subgroups for multivariable analysis: sepsis hospitalizations, alcohol and drug related hospitalizations, and diabetes related hospitalizations. We required patients in the sepsis group to have a primary or secondary sepsis ICD-9 code based on the definition from Martin et al. (ICD-9 codes: 038.x, 020.0, 790.7, 117.9, 112.5, and 112.81 and then further expanded to include newer codes of 995.91 and 995.92) [19]. Patients in the sepsis subgroup were further required to have billing charge codes indicating a blood culture by day 2 and antibiotics given orally or intravenously by day 2. We defined the alcoholism and drug abuse cohort by the MS-DRGs of: 894, 896, 897, 917, 918, 922, 923. We defined the diabetes cohort by the MS-DRGs of 637, 638, and 639 (see Supplemental Table 3). We note that the latter subgroups could have sepsis (i.e., the subgroups are not mutually exclusive).

2.1. Statistical analysis

We used multivariable logistic regression with robust standard errors clustered at the hospital level to predict in-hospital mortality. Since patients could have multiple hospitalizations during the study period, one randomly chosen hospitalization was used in the mortality analysis for patients with multiple hospitalizations during the study period. To analyze LOS and ICU LOS, we used all eligible hospitalizations in generalized estimating equations with robust standard errors that had a logarithmic link and assumed the outcomes followed a gamma distribution. We present adjusted results as odds ratios and marginal mean differences with 95% confidence intervals (CIs). All models adjusted for homeless status (present or absent), age, demographics, insurance type, Elixhauser comorbidities, pneumonia present on admission, organ supportive therapies (e.g., mechanical ventilation dialysis), and other treatments present by day 2 of the patient's hospitalization (see Table 1, Table 2, and Supplemental Table 4). The regression models for the alcohol and drug related DRG group and the diabetes group were also adjusted for the presence of sepsis. For the overall cohort, homeless versus non-homeless patients were compared using the *t*-test for continuous variables and the chi-square test for categorical variables unless a cell count was <5, whereby Fisher's exact test was used. All *p*-values <.05 were considered to be statistically significant. All analyses were done using Stata/MP 15.1 for Windows (StataCorp, LP, College Station, TX).

Table 1
Patient demographics by homeless status.

Variable	Not Homeless ($N =$ 779,262)	Homeless ($N =$ 2278)	P-value
Age; Mean (Standard Deviation)	62.8 (17.2)	47.8 (12.0)	<0.001
Age Category (in years)			
18 to 49	21.2%	49.3%	
50 to 59	18.2%	37.7%	<0.001
60 to 69	21.6%	10.5%	
70 to 79	20.3%	2.3%	
80+	18.7%	0.2%	
Male Gender	53.3%	80.7%	<0.001
Race			
White	68.2%	64.7%	
Black	11.8%	13.6%	<0.001
Hispanic	4.1%	3.6%	
Other	15.8%	18.1%	
Marital Status			
Married	42.4%	5.1%	
Single	48.8%	83.6%	<0.001
Other	8.9%	11.3%	
Insurance Type			
Medicare (Traditional or Managed)	55.4%	15.1%	
Medicaid Traditional	7.2%	26.3%	
Medicaid Managed	3.2%	9.7%	
Managed Care	18.0%	3.0%	<0.001
Commercial Indemnity or Workers Compensation	5.9%	1.5%	
Self-Pay/Other/Unknown	10.4%	44.3%	
Medical (Vs Surgical) Patients by Medicare Severity Diagnosis Related Groups Definitions	60.2%	83.0%	<0.001
Hospital Characteristics			
Number of Beds			
<199	14.4%	12.5%	
200 to 299	16.8%	19.4%	
300 to 399	19.7%	22.2%	<0.001
400 to 499	17.4%	19.1%	
500+	31.7%	26.9%	
Urban location	89.3%	93.2%	<0.001
Census Region			
Midwest	22.6%	12.6%	
Northeast	16.0%	12.1%	<0.001
South	41.9%	27.5%	
West	19.5%	47.8%	

3. Results

3.1. Patient characteristics and outcomes in the full cohort

781,540 patient hospitalizations from 417 hospitals met inclusion criteria and 2278 (0.29%) were homeless adults admitted to the ICU by day 2 of their hospitalization as detailed in Supplemental Table 2. Of the 781,540 hospitalizations there were 690,576 unique patients (88.3%) and there were 2138 unique patients among the 2278 homeless admissions (93.9%). Demographics differed markedly by homeless status. See Table 1. Homeless patients were substantially younger than non-homeless patients with just 2.6% of homeless patients being age 70 or older compared to 39.0% of non-homeless patients, $p < .001$. See

Table 2
Elixhauser defined chronic comorbidities by homeless status.

Elixhauser comorbidity	Non-homeless patients N = 779,262	Homeless patients N = 2278	P-value
Congestive heart failure	13.7%	6.2%	<0.001
Valvular disease	5.4%	1.9%	<0.001
Pulmonary circulation disease	4.9%	2.2%	<0.001
Peripheral vascular disease	11.8%	4.4%	<0.001
Paralysis	3.9%	1.8%	<0.001
Other neurological disorders	10.7%	17.1%	<0.001
Chronic pulmonary disease	26.1%	23.1%	0.001
Diabetes w/o chronic complications	24.8%	11.1%	<0.001
Diabetes w/ chronic complications	6.1%	3.9%	<0.001
Hypothyroidism	12.4%	4.4%	<0.001
Renal failure	18.2%	5.7%	<0.001
Liver disease	3.8%	14.6%	<0.001
Peptic ulcer disease x bleeding	0.0%	0.0%	0.39
Acquired immune deficiency syndrome	0.2%	0.4%	0.003
Lymphoma	0.9%	0.2%	<0.001
Metastatic cancer	3.0%	0.6%	<0.001
Solid tumor w/out metastasis	4.0%	1.5%	<0.001
Rheumatoid arthritis/collagen vascular disease	2.9%	0.8%	<0.001
Coagulopathy	10.3%	16.2%	<0.001
Obesity	13.4%	6.6%	<0.001
Weight loss	8.6%	11.8%	<0.001
Fluid and electrolyte disorders	38.0%	47.5%	<0.001
Chronic blood loss anemia	2.1%	1.5%	0.06
Deficiency anemias	23.7%	22.7%	0.26
Alcohol abuse	7.1%	45.5%	<0.001
Drug abuse	4.6%	29.3%	<0.001
Psychoses	6.0%	25.6%	<0.001
Depression	11.9%	16.4%	<0.001
Hypertension, uncomplicated	44.6%	33.4%	<0.001
Hypertension, complicated	11.7%	4.4%	<0.001

Supplemental Fig. 1. Homeless patients were also significantly more likely to be male, single, uninsured, and assigned a non-surgical (i.e., medical) DRG.

Chronic comorbidities differed by homeless status as well. See Table 2. Homeless patients had more liver disease and neurological disorders and histories of chronic alcohol abuse, drug abuse, psychoses, and depression but less congestive heart failure, renal failure, obesity, and cancer than the non-homeless patients. Supplemental Table 4 describes a series of common interventions by day 2 of ICU admission by homeless status. Notably, both homeless patients and non-homeless patients had similar rates of mechanical ventilation by day 2 (24.8% vs 23.8% respectively, $p = .30$). However, homeless patients were significantly less likely to receive vasopressors, dialysis, inotropes, neuroblockers, colloidal fluids, morphine, and opioids suggesting a less acutely ill population. Homeless patients received substantially more thiamine by day 2 which likely reflects the high prevalence of alcoholism in these patients. In the sepsis cohort, 32.2% of the homeless patients and 28.5% of the non-homeless patients had an ICD-9 code for pneumonia that was present on admission ($p = .21$).

Table 3 details the discharge location, length of stay, and mortality outcomes. In the unadjusted analysis, homeless patients had a lower in-hospital mortality rate compared to non-homeless patients (4.78% vs 8.42%, $p < .001$) and longer mean (SD) LOS values: 8.3 (12.0) days versus 6.8 (7.9) days, $p < .001$). However, median LOS values did not differ, suggesting a disproportionate share of extreme lengths of stay in the homeless population. Also, mean ICU LOS was similar (approximately 3.5 days) in both groups ($p = .82$). A majority of both homeless and non-homeless patients were discharged under "Home or Self-Care." However, homeless patients had a substantially higher rate of "Left Against Medical Advice" discharges (8.3% vs 1.2%, $p < .001$) and discharges to psychiatric hospitals (8.0% vs 1.4%, $p < .001$).

Supplemental Table 2 presents the top 25 MS-DRG values for the homeless patients. As expected, DRGs related to the effects of drug abuse and alcoholism were common. Also prevalent were DRGs related to sepsis, respiratory system diagnoses, and complications from diabetes. The top 25 MS-DRG values represented 57.2% of the homeless patients and no DRG was prevalent in >8% of the patients suggesting that the homeless cohort had some diversity in etiology for ICU admission.

Table 3
Mortality rates, length of stay, and discharge location by homeless status.

Outcome	Homeless N = 2278	Not homeless N = 779,263	P-value
Intensive Care Unit Length of Stay (Days); Mean (SD)	3.5 (5.7)	3.6 (4.9)	0.82
Length of Stay (Days); Mean (SD)	8.3 (12.0)	6.8 (7.9)	<0.001
Length of Stay (Days); Median [25th percentile, 75th percentile)	5 [2, 9]	5 [3,8]	0.13
Length of Stay (Days) for Survivors Only; Mean (SD)	8.3 (12.2)	6.8 (7.6)	<0.001
ICU Length of Stay (Days); Mean (SD)	3.5 (5.7)	3.6 (4.9)	0.82
ICU Length of Stay (Days); Median [25th percentile, 75th percentile]	2 [1,3]	2 [1, 4]	<0.001
Died in Hospital	4.8%	8.4%	<0.001
For survivors of hospitalization:			
Discharged to Home or Self-Care	61.76%	52.0%	
Left Against Medical Advice	8.3%	1.2%	
Discharged to a Skilled Nursing Facility	8.2%	12.7%	
Discharged to a Psychiatric Hospital	8.0%	1.4%	
Discharged to Another Location	4.0%	2.1%	
Discharged to Home Health Organization	2.2%	13.6%	<0.001
Discharged to Another Rehabilitation Facility	1.6%	4.4%	
Discharged to an Intermediate Care Facility	0.6%	0.7%	
Discharged to a Long-term Care Facility Hospital	0.5%	1.7%	
Discharged to Hospice	0.1%	1.7%	

3.2. Multivariable analysis

Tables 4 and 5 present the multivariable adjusted results examining mortality and length of stay (LOS) as outcomes. There was no association with homelessness and in-hospital mortality in the sepsis patients. The adjusted mortality rate for homeless patients was 23.1%; 95% CI (17.5% vs 28.7%) versus 25.1%; 95% CI (24.5%, 25.8%) in the non-homeless patients. This translates into an odds ratio = 0.87; 95% CI (0.59, 1.28), $p = .48$. Supplemental Table 5 presents the logistic regression results of the full model among the sepsis cohort. In-hospital mortality was too rare in the homeless patients in the alcohol and drug related group and in the diabetes group for valid inferences.

In the LOS analyses, homelessness was associated with longer hospitalizations (3.7 days longer; 95% CI (1.7, 5.7), $p < .001$) among sepsis patients. However, ICU LOS did not differ by homeless status. For both the alcohol and drug related DRG group and the diabetes group, homelessness had no association with LOS and homeless patients had statistically shorter ICU LOS values though the differences were modest. A sensitivity analysis examining LOS for survivors produced similar results. See Table 5.

4. Discussion

In this study of over 2000 homeless critically ill patients we found that homeless patients are a clinically distinct population in the ICU. Homeless patients were younger, more likely to be male and have certain comorbidities such as alcoholism, drug abuse, psychoses, and liver disease than non-homeless patients. This implies that interventions not always used in the ICU (e.g., substance abuse treatment) may benefit this population. In addition, the rate of mechanical ventilation within the first 2 days of hospitalization was similar to non-homeless patients

Table 4
Multivariable adjusted in-hospital mortality results.

Cohort; $N = 80{,}216$ unique patient encounters $n = 211$ (0.26%) Homeless patients	Homeless patients Adjusted marginal mortality rate	Non-homeless patients Adjusted marginal mortality rate	Odds ratio; 95% CI	P-value
Sepsis diagnosis with both antibiotics and a blood culture by Day 2	23.1%; (17.5%, 28.7%)	25.1%; (24.5%, 25.8%)	0.87; (0.59, 1.28)	0.48

in the ICU and 10.1% of the homeless hospitalizations met the inclusion criteria for the sepsis cohort.

Several findings warrant comment compared to the limited results in the literature from the multivariable analyses. Bigé et al. studied 421 homeless patients in a single medical ICU in France from 2000 to 2012 and found that homeless patients had longer lengths of stay but similar mortality compared to non-homeless ICU patients [20]. Conversely, a smaller Canadian study of 63 critically ill homeless patients that propensity matched homeless to non-homeless patients also found homeless patients had an increased risk of mortality but not LOS [21]. In addition, studies from Germany and Australia that examined low SES but not necessarily homeless patients who were critically ill, found low SES to be associated with longer ICU lengths of stay and higher mortality [22,23]. Studies examining LOS in a general hospitalized population (and not necessarily among those in the ICU) also found an increase LOS associated with homeless patients [24,25].

Our results based on more homogeneous critically ill patients in a larger dataset show no mortality association with homelessness but that homeless patients have significantly longer LOS (but not ICU LOS) values when diagnosed with sepsis. The similar lengths of stay in patients with alcohol or drug related DRGs and with diabetes related DRG by homeless status are novel observations and indicate that the impact of homelessness on length of stay varies depending on the reasons for admission (e.g., sepsis vs a drug overdose or diabetic ketoacidosis). We note that non-homeless critically ill patients are rarely admitted with intoxication and are unlikely to let diabetes-related complications like hyperglycemia get to a point that requires an ICU admission which suggests that these homeless patients may be less acutely ill than their non-homeless peers with the same DRGs.

Notably ICU LOS was similar (or slightly shorter) by homeless status in the overall study population and by subgroups. This finding combined with the multivariable results and the observation that homeless patients tended to receive fewer drug and procedural interventions early in the ICU stay further supports that what is driving the additional length of stay in the homeless patients with sepsis is not illness severity but the inability to place these patients to a proper location once they are ready to be discharged. Hospital personnel (e.g., social workers, nurses, and physicians) responsible for post-discharge placement and treatment plans should anticipate a challenging situation when a critically ill homeless patient is healthy enough for discharge. Further

Table 5
Multivariable adjusted length of stay results.

Length of stay (LOS)	Sample size N; n (%) Homeless	Homeless patients Adjusted LOS in days	Non-homeless patients Adjusted LOS in days	Adjusted difference in LOS in days; 95% CI	P-value
Sepsis diagnosis with both antibiotics and a blood culture by Day 2	93,059; 230 (0.2%) Homeless	14.8; (12.7, 16.0)	11.0; (11.0, 11.1)	3.7; (1.7, 5.7)	**<0.001**
Medicare Severity Diagnosis Related Groups (MS-DRGs) related to Alcohol and Drugs	32,651; 594 (1.8%) Homeless	3.9; (3.7, 4.2)	3.7; (3.7, 3.8)	0.2; (−0.1, 0.5)	0.10
MS-DRGs related to Diabetes	20,422; 166 (0.8%) Homeless	4.0; (3.6, 4.4)	3.9; (3.8, 3.9)	−0.1; (−0.2, 0.5)	0.49

Length of stay for survivors	Sample size N; n (%) Homeless	Homeless patients Adjusted LOS in Days	Non-homeless patients Adjusted LOS in Days	Adjusted difference in LOS in days; 95% CI	P-value
Sepsis diagnosis with both antibiotics and a blood culture by Day 2	71,190; 187 (0.3%) Homeless	16.2; (13.9, 18.5)	11.9; (11.9, 12.0)	4.2; (1.9, 6.5)	**<0.001**
MS-DRGs related to Alcohol and Drugs	31,893; 590 (1.8%)	3.9; (3.7, 4.2)	3.7; (3.7, 3.8)	0.2; (0.0, 0.5)	0.08
MS-DRGs related to Diabetes	20,237; 166 (0.8%) Homeless	4.0; (3.6, 4.4)	3.8; (3.8, 3.9)	−0.1; (−0.2, 0.5)	0.47

ICU length of stay	Sample size N; n (%) homeless	Homeless patients Adjusted LOS in Days	Non-homeless patients adjusted LOS in days	Adjusted difference in LOS in days; 95% CI	P-value
Sepsis diagnosis with both antibiotics and a blood culture by Day 2	93,059; 230 (0.2%) Homeless	5.9; (5.0, 6.7)	5.9; (5.9, 6.0)	0.0; (−0.9, 0.8)	0.92
MS-DRGs related to Alcohol and Drugs	32,651; 594 (1.8%) Homeless	2.0; (1.9, 2.1)	2.2; (2.2, 2.2)	−0.2; (−0.3, 0.0)	**0.01**
MS-DRGs related to Diabetes	20,422; 166 (0.8%) Homeless	1.7; (1.6, 1.9)	1.9 (1.8, 1.9)	−0.1; (−0.3, 0.0)	**0.04**

P-values < 0.05 are highlighted in boldface.

complicating discharge planning for these patients is that a large number (8.25%) in our analysis left against medical advice—a rate that was 7 times higher than the non-homeless ICU patients.

Finding an appropriate post-hospital care setting is necessary to avoid delayed discharges (i.e., patients remain in the hospital but are medically able to be discharged). Obviously this is much more difficult for homeless patients. Delayed discharges can have considerable impact on patient flow as these patients can "block" others from being admitted to the hospital floor from the emergency department when census is high [26]. Discharge planning has received increased interest as a means of reducing resource use and improving outcomes in high-risk patients [27]. Greysen et al. found that a formal assessment of a homeless patient's housing status prior to discharge was associated with improved quality of discharge care [28].

Formal medical respite programs have recently been initiated to accommodate homeless patients after discharge from acute hospital stays [29]. These programs provide housing and health care for homeless patients too sick to be in a traditional homeless shelter but not acutely ill enough to require inpatient hospitalization [30]. Respite programs are associated with reducing 90-day readmission rates which is important given that readmissions are common in these patients [29-32]. Unfortunately, these programs are not available in all parts of the country and those that do exist typically have very high occupancy rates (e.g., a Boston respite program, one of the largest in the country, generally runs above 90% capacity) [29].

While this study appears to be the largest to date that examines critically ill patients in the United States, it does have some limitations. First, we were unable to adjust for laboratory values in our multivariable modeling but we did adjust for initial treatments (e.g., vasopressors, inotropes, mechanical ventilation, dialysis) indicative of hemodynamic instability or organ failure. Second, some patients who were homeless may not have been coded with an ICD-9 V60 code and so were misclassified (and undercounted) though this code has been used by other researchers to identify homeless patients [33]. Peterson et al. recommend expanding the definition of homelessness based on other administrative data and ICD-9 codes to decrease misclassification [34]. Third, the availability of medical respite or similar programs near the hospitals in the Premier database is unknown and may have influenced patient length of stay. Fourth, the study period was before the current "opioid crisis" which may affect the outcomes among patients now admitted for a drug related DRG [35]. Fifth, it is unknown if homelessness influenced the decision to admit a patients to the ICU. Finally, the epidemiology of homeless patients in ICU in other countries or in the United States but outside the Premier database is unknown, particularly since large, inner-city hospitals are underrepresented in the Premier database.

In conclusion, homeless patients represent a small but clinically unique and challenging population in the ICU. These patients tend to be younger than typical ICU patients and are more likely to present with mental health and drug or alcohol related comorbidities. Homeless status is not correlated with an increased mortality risk in select critically ill patients but homeless patients with sepsis had longer hospitalizations. Thus, while critical care is effective for these patients, clinicians need to better coordinate how and where homeless patients will be discharged post-ICU to optimized resource use and improve the long-term health of these patients.

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